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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

The Counties of California

MINERAL RESOURCES
AND
MINERAL PRODUCTION
DURING 1947

BULLETIN 142
1949

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FERRY BUILDING, SAN FRANCISCO

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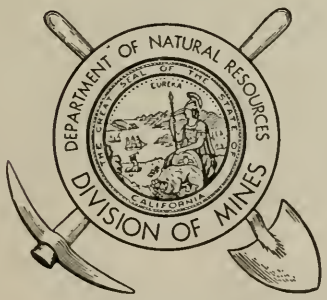
DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO 11
OLAF P. JENKINS, Chief

SAN FRANCISCO | BULLETIN 142 | JULY 1949

THE COUNTIES OF CALIFORNIA

MINERAL RESOURCES AND MINERAL PRODUCTION DURING 1947

Prepared under the direction of
OLAF P. JENKINS



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LETTER OF TRANSMITTAL

To His Excellency
The Honorable Earl Warren
Governor of the State of California

Dear Sir:

I have the honor to transmit herewith Bulletin 142, *The Counties of California—Mineral Resources and Mineral Production During 1947*, prepared under the direction of the Chief of the Division of Mines, Olaf P. Jenkins. This bulletin represents the Division's annual publication on mineral statistics including, as a special feature, a summary of the mineral resources of each and every county in the state. For the first time all the essential features of mineral information concerning the separate counties have been assembled under one cover: general geologic features, mineral resources, significant mining activities during 1947, and mineral production. It is the first statistical bulletin which contains the results of the cooperative agreement entered into with the federal Bureau of Mines whereby the latter organization gathers and processes the production figures directly from the producers. These figures, however, as they became available, have previously been released in the Division's monthly pamphlet, *Mineral Information Service*.

The general preparation of Bulletin 142 was done by Charles V. Averill, Supervising Mining Engineer of the State Division of Mines. Other contributing authors were Oliver E. Bowen, Jr., Fenelon F. Davis, Clarence A. Logan, Lewis A. Norman, Jr., John C. O'Brien, Reid J. Sampson, Richard M. Stewart, Henry H. Symons, and William E. Ver Planck, Jr., all members of the staff of the Division of Mines.

In number of different mineral substances produced, California stands first among the states of the Union. Each year at least 60 different kinds of minerals and rocks are produced commercially. In value of annual mineral production, California ranks third among the states, exceeded by Texas because of its large petroleum and natural-gas production, and by Pennsylvania because of its vast coal resources.

While this bulletin features the counties of the state, it is intended that the next annual volume will emphasize the mineral commodities. In this way the public will be provided with two invaluable reference books on the commercial minerals of the state, which do not duplicate the order of presentation.

Respectfully submitted,

WARREN T. HANNUM, Director
Department of Natural Resources

February 1949

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PREFACE

It has long been the practice of the Division of Mines to issue each year a statistical bulletin known as *Mineral Production of California.* This bulletin has always included much more information than merely that of mineral statistics. Short descriptions of the mineral commodities and the counties which produce minerals have always been included. Generally a list of the mineral producers and other pertinent data have been added.

This year special emphasis has been placed on the mineral resources of the 58 counties in California, each of which have contributed to the mineral wealth of the state. General geologic features, occurrences and production of minerals, and principal mining operations are the subjects discussed. Statistical data are also added to these descriptions, making the whole volume a text to the mineral resources of the state by counties.

Part 1 consists of a brief summary of the mineral commodities in the state, with a table showing the quantity and value of each of the mineral substances produced. In addition, a statement and table are given to show the total value of minerals produced in each county. Several graphs are included to indicate relationship between California and other leading mineral-producing states and the relationship between the principal mineral-producing counties of California.

Part 2 forms the bulk of the bulletin and is devoted to treating each county briefly in the following manner:

General geologic features
Mineral resources
Significant activities during 1947
Table of mineral production

Part 3 does not contain any descriptions but is intended to serve as a directory of mineral producers and to give useful lists of smelters, mineral dealers, custom mills, commercial grinding plants, buyers of quicksilver, assayers, and testing laboratories.

It is intended that the annual statistical report for 1948 will describe in more detail the occurrences, uses, and production of mineral commodities as such rather than by counties. In the following year, the bulletin may be devoted to marketing minerals. In this manner it is hoped that these annual mineral production bulletins will serve a lasting value as texts to all phases of the mineral resources and industry of the state.

In preparing this bulletin, various members of the technical staff of the Division of Mines have contributed. The author for each section is indicated by his initials after the section.

In order to improve the manner of gathering and assembling mineral statistics without duplication between federal and state agencies, an agreement has recently been made between the California State Division of Mines and the United States Department of the Interior, Bureau of Mines. The statistics of this bulletin are the result of this cooperative undertaking.

AGREEMENT

This agreement made and entered into this 1st day of May, 1948, between the United States Bureau of Mines and the Division of Mines of the State of California for cooperation in the collection of statistical data:

In order to avoid duplication of requests for statistical information of mine and quarry operations, and also in order that the State Division of Mines may be kept in touch with the mineral producers of the State, the following agreement between the Chief, State Division of Mines, and the Director of the United States Bureau of Mines is made for the collection of statistics of mineral production (with the exception of oil and gas) for 1947 and subsequent years. The type and scope of statistics to be secured from producers will be determined by consultation between the Bureau and the Division in order to comply with Section 2205(b) of the California Public Resources Code.

As soon as possible after the first of December, in each year, a numbered list of the mineral producers in the State (a duplicate of the working list of the Federal Bureau of Mines) will be sent by the Bureau of Mines to the Chief, Division of Mines to be retained for his files. The Chief will check the data with the records of his office and will notify the Federal Bureau of Mines at once of any additions and corrections to the list he deems advisable. These corrections will be made on the list of the Federal Bureau of Mines, properly numbered, and the Division of Mines will be advised of the list number given.

The blanks for the collection of the statistical data from mineral producers will be printed at the expense of the United States Bureau of Mines and stamped "In cooperation with the Division of Mines, Department of Natural Resources, State of California, under Division 2 of the California Public Resources Code." The statistical inquiries will be mailed from the United States Bureau of Mines.

The second statistical inquiry will be prepared in the Federal Bureau of Mines in the same manner as the first inquiry. The third will be sent by registered mail. This procedure will be so scheduled as to provide annually for receipt by Bureau of Mines, by March thirty-first, of all statistical reports from mineral producers. If this procedure does not produce satisfactory results, the Chief, Division of Mines, will endeavor to induce delinquent respondents to cooperate in the Federal Bureau's voluntary statistical collection program, by personal visits of himself or his assistants or by such other means as he may deem advisable.

The returns from the operators will not be forwarded through the Division of Mines but will be received by the Federal Bureau of Mines direct from the operators, provided, however, that the Chief, Division of Mines, may invoke his powers under Sections 2207 and 2208 of the California Public Resources Code, and may supply information so obtained to the Federal Bureau of Mines.

The figures covering the total output of each mineral in the State, with such county break-down as is possible without revealing information obtained in confidence, will be sent to the Division of Mines as soon as the compilation of the data is completed. Figures representing the output of less than three producers shall not be disclosed, unless the Federal Bureau of Mines has obtained in writing authorization therefor from the producers interested.

In publications relating to the minerals covered by this cooperative agreement, issued by either the Federal Bureau of Mines or the Division of Mines, proper credit for cooperation shall be given.

The term of this agreement shall be from May 1, 1948 to April 30, 1953, inclusive, but shall be subject to termination by either party at any time during the term upon giving sixty days' written notice to the other party.

APPROVED:

WARREN T. HANNUM
Director of Natural Resources
State of California

JAMES BOYD, Director
U. S. Bureau of Mines

APPROVED:

DEPARTMENT OF FINANCE
JAMES S. DEAN, Director
By LOUIS J. HEINZER
Administrative Adviser

OLAF P. JENKINS, Chief
Division of Mines
Department of Natural Resources
State of California

In order to make the production figures available to the public as quickly as possible, they have been published as they have been released, in the pamphlet *Mineral Information Service* published monthly by the Division of Mines.

It is hoped that this new arrangement of releasing data as compiled and then assembling all data in a more comprehensive treatise on mineral resources will be found useful to both producers and users of the vast mineral reserves of this great State of California.

Olaf P. Jenkins
Chief, Division of Mines

March 11, 1949

PART 1

SUMMARY OF THE MINERAL RESOURCES OF CALIFORNIA

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INTRODUCTION

The growth of mineral industries always has been closely associated with the advance of civilization. The nations which have developed abundant mineral resources have been the most progressive and influential of the world.

The use of minerals dates far back in the history of Man. First, stones were shaped into weapons, then mud and stones were used for the construction of crude huts. Next it was discovered that some clays could be shaped, hardened by firing, and made into utensils. Later, metals were found, first in their native state, then as ores from which the metals were extracted. Still later it was found that the mineral coal could be used as fuel. Finally, petroleum was discovered. The discovery of mineral fuels has speeded the advance of industry more than any other event. It has given man luxuries and power and the means of attaining a high standard of living.

California has a greater variety of minerals of possible commercial importance than any comparative area in the world. Mineral fuels—petroleum and natural gas—are found in the oil fields of the Los Angeles Basin, the southern coastal areas, and the southern San Joaquin Valley. Natural gas is also found in abundance in central and northern California. Coal is known to occur in several localities in the state, and was mined in the early days; but at the present time, it is of little economic importance.

Metals are widely distributed throughout the state. Gold, which set the record for production for many years, was finally passed in value by petroleum in 1907. Other metals found in California ores in commercial quantities are quicksilver, copper, silver, tungsten, iron, chromium, manganese, lead, zinc, platinum-group metals, molybdenum, magnesium, and antimony.

Industrial nonmetallic minerals are extremely abundant, and from them many of the industries of the state derive their raw materials. Among the more important commercial nonmetallic minerals are barite, diatomite, gypsum, limestone, pumice and pumicite, quartz, sulfur and pyrite, talc, soapstone, and pyrophyllite.

California is fortunate in having several important occurrences of saline minerals. Borates come from the colemanite deposits of Death Valley, from the kernite deposits of the Kramer district, and from saline lakes in Inyo and San Bernardino Counties. Sodium salts are derived from desert lakes, iodine from oil-well brines, and salt from coastal bays and desert lakes.

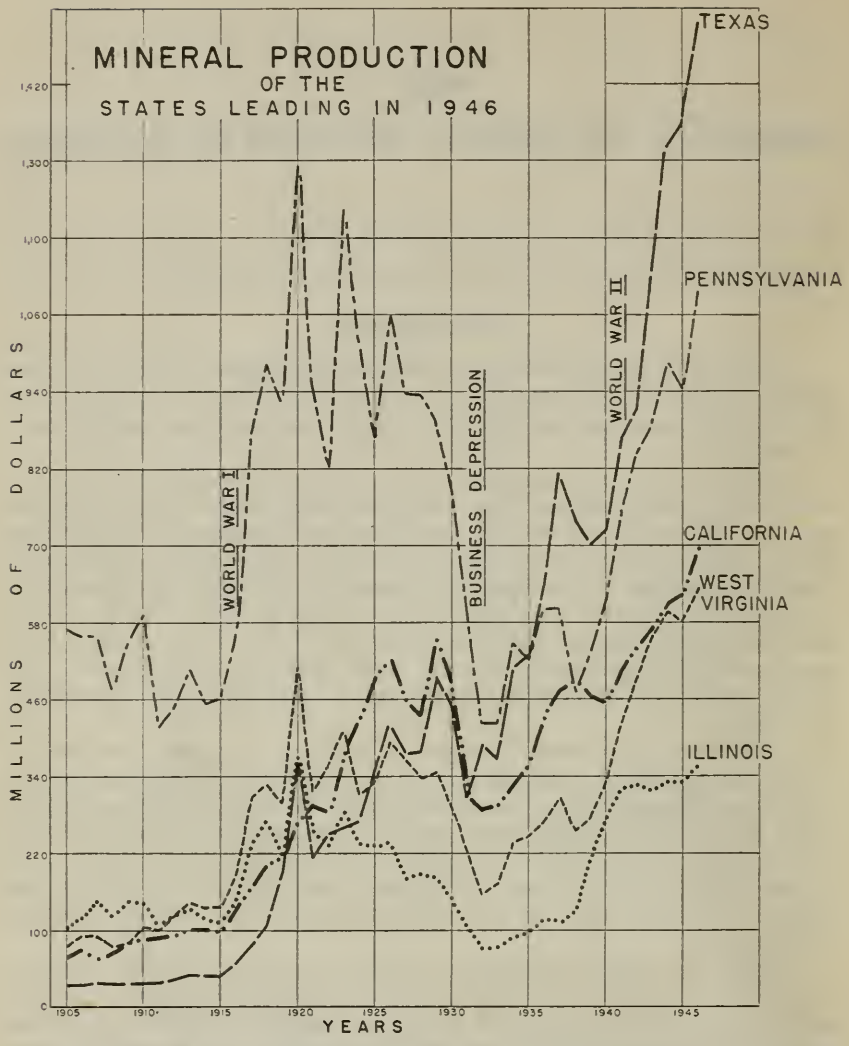


FIGURE 1. Mineral production of the five states leading in 1946. Texas leads because of oil and gas production; Pennsylvania is second because of coal production; California has the largest number of commercial minerals.

MINERAL SUBSTANCES PRODUCED IN CALIFORNIA DURING 1947

The total value of the mineral output in California for the year 1947 was $855,553,000, an increase of $263,259,000 over the 1946 total value of $592,294,000, as compiled by the U. S. Bureau of Mines. The large increase in total value of the state's mineral output was chiefly brought about by an unprecedented demand for petroleum and natural gas and the resulting higher prices. A total of 53 commercial mineral substances was produced during the year. All 58 counties of the state contributed to the production.

Asbestos. All the asbestos produced during 1947 was of the amphibole variety and came from two properties in Shasta County and one in Placer County. The year's output showed a decrease in both quantity and total value as compared with that of 1946.

Asphalt (Native). Native asphalt produced during 1947 came from a single property in Santa Cruz County. The material being shipped is also referred to as bituminous sand, and it is used as road surface. The 1947 shipments showed a slight decrease in both quantity and value as compared with those of 1946.

Barite. Shipments of barite from California deposits during 1947 came from single properties in Mariposa and Plumas Counties. The material from Mariposa County was used chiefly to give weight to oil-well drilling muds, and that from Plumas County was shipped to a plant at Modesto where barium chemicals are manufactured. Compared with that of 1946, the 1947 output showed a slightly smaller tonnage and a higher value. Barium pigments are manufactured from barite produced in Nevada.

Boron Minerals (Borates). Shipments of borates from California deposits totaled 501,935 short tons valued at $11,844,108, and came from two properties in Inyo County, two properties in San Bernardino County, and one property in Kern County. In 1946 shipments totaled 430,689 short tons worth $9,575,866. The above figures include the sodium borates (kernite and kramerite) from Kern County; a small amount of colemanite from Inyo County; and crystallized borax prepared by evaporation of the brines at Searles Lake, San Bernardino County and Owens Lake, Inyo County. California is the leading source of the world's borates supply. The 1947 output was the largest ever reported for the state.

Bromine. The bromine produced in California during 1947 was recovered from sea-water bitterns from the salt works of San Francisco Bay and brines from Searles Lake, San Bernardino County. The chief use of the bromine is in the manufacture of ethylene dibromide, which is used in tetraethyl lead for ethyl gasoline. The 1947 output showed an increase over that of 1946.

Calcium Chloride. The calcium chloride produced in California during 1947 came from the salt deposits on Bristol Lake near Amboy, San Bernardino County, and totaled 7,968 short tons valued at $111,950. The 1946 production was 9,979 short tons, worth $170,994.

Carbon-Dioxide Gas. The carbon dioxide produced in California during 1947 came from wells near Niland, Imperial County; and wells near Hopland and Ukiah, Mendocino County. Nearly all the carbon dioxide was used in the manufacture of dry ice, and the year's output showed an increase in both amount and value over that of 1946.

Cement. Cement was produced in California during 1947 from three mills in San Bernardino County and one mill in each of the following counties: Calaveras, Kern, Los Angeles, Riverside, San Benito, San Mateo, Santa Clara, and Santa Cruz. Production totaled 22,790,000 barrels in 1947, and 19,545,000 barrels in 1946. Shipments of cement in 1947 for the state totaled 22,846,458 barrels worth $46,539,749; for 1946, the total was 20,173,231 barrels worth $33,906,675. The annual capacity of California cement mills was increased from 25,770,000 barrels in 1946 to 26,070,000 barrels in 1947. In 1947 California was the leading state in the consumption of cement, and ranked second to Pennsylvania in cement production.

Chromite. The chromite mined and shipped in California during 1947 came from single properties in Butte and Del Norte Counties. The 1947 output totaled 948 short tons and showed a slight increase over that of 1946.

Clay. The clay sold or used in California totaled 1,950,076 short tons valued at $2,965,360 during 1947, and 1,670,305 short tons worth $2,254,164 during 1946. Of the 1947 production, 16,359 short tons worth $278,489 were kaolin and came from properties in Kern, Orange, and San Bernardino Counties; 487,081 short tons worth $1,069,017 were fire clay and came from properties in Alameda, Amador, Los Angeles, Orange, Placer, Riverside, Sacramento, Santa Clara, and Stanislaus Counties; and 5,328 short tons worth $55,500 were bentonite and came from properties in Inyo, San Benito, San Bernardino, and San Diego Counties.

A total of 1,441,308 short tons of miscellaneous raw clay valued at $1,562,354 was produced in Alameda, Calaveras, Contra Costa, Fresno, Humboldt, Inyo, Kern, Los Angeles, Marin, Placer, Riverside, San Bernardino, San Diego, San Joaquin, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Sutter, and Ventura Counties. Part of the clay from Kern and Ventura Counties was used as oil-well drilling mud; and part of the clay from Calaveras, Kern, Riverside, San Bernardino, Santa Clara, and Santa Cruz Counties was used in the manufacture of cement.

Heavy clay products (other than pottery and refractories) produced in California during 1947 had a total value of $16,793,000, as compared with $12,175,000 in 1946. Plants were operated in Alameda, Amador, Contra Costa, Fresno, Humboldt, Kern, Los Angeles, Marin, Orange, Placer, Riverside, Sacramento, San Bernardino, San Diego, San Joaquin, San Luis Obispo, Santa Barbara, and Santa Clara Counties. The largest production came from Los Angeles County where approximately 24 plants manufactured these products; the San Francisco Bay area ranked second in production with five plants in Alameda County, six plants in Contra Costa County, and four plants in Santa Clara County.

Coal. During 1947 a small amount of lignite was produced from a mine at Ione, Amador County, and was sent to a new plant which extracts montan wax by a chemical process. Montan wax is used in pigments and as a waterproofing material. During the year some development work was done on coal properties at Dos Rios, Mendocino County. Coke is made at a California iron and steel plant from coal imported from Utah.

Copper. A total of 4,814,000 pounds of copper worth $1,010,940 was produced in California during 1947; the 1946 production was 8,480,000

pounds worth $1,373,760. The Newton mine, operated by Pacific Mining Company, near Ione, Amador County, was the largest producer and, before it shut down on August 1, accounted for nearly one-third of the state's output of copper. Other large producers during the year were the Penn mine of the Shawmut Copper Company, at Campo Seco, Calaveras County; and the Hornet mine of the Mountain Copper Company, Ltd., at Matheson, Shasta County. By the end of July 1947, all copper-zinc mines in California suspended production because of the high cost of operation, the low grade of the ore, and the expiration of the government premium price plan. The average New York quotation on copper for the year 1947 was 20.9 cents per pound and that for 1946 was 14.4 cents; the December 22, 1948, quotation on copper was 23.4 cents per pound.

Diatomite. The quantity and value of diatomite shipped during 1947 were the largest for one year ever reported in the state. Diatomite was produced from single properties in Inyo, Los Angeles, Santa Barbara, and Siskiyou Counties. California leads all the states in the output of this mineral.

Feldspar. During 1947 a small amount of feldspar was reported to have been shipped from a property in Madera County. No feldspar was produced in 1946.

Fullers Earth. See bentonite under clay.

Gem Stones. Some renewed activity was reported in the gem mines at Pala, San Diego County. A pocket yielding several pounds of gem-quality kunzite, and other smaller pockets were found. In Yuba County a small diamond was reported recovered from a gold placer.

Gold. California produced 431,415 fine ounces of gold valued at $15,099,525 during 1947, and 356,824 fine ounces worth $12,488,840 during 1946. Of the 1947 gold output the lode or deep mines accounted for 118,877 fine ounces worth $4,160,695; the placer mines (mainly bucketline and dragline dredges) produced 312,538 fine ounces worth $10,938,830.

Sacramento County led the counties in the value of gold yield for 1947 with a total of $3,974,600; Nevada County was second with a total value of $2,846,550; Yuba County third with $2,302,580; followed by Butte, Siskiyou, Stanislaus, and Merced Counties. The gold produced in Nevada County was derived in approximately equal amounts from the placers and the deep or lode mines, but production from the other leading counties was almost entirely from placer deposits.

The following quotation from Merrill [1] gives an outline of gold mining activities for the year 1947:

"The Yuba Consolidated Gold Fields operated five dredges in the Yuba River district, Yuba County, during 1947, two in Butte County and one in Siskiyou County, which resumed operation in September following a shutdown since April 1946. The Natomas Co. operated their entire fleet of seven dredges in the Folsom district, Sacramento County, during 1947. The Gold Hill Dredging Co. operated two dredges on the Mokelumne River, Camanche district, San Joaquin County, and one dredge on the Feather River, Oroville district, Butte County. Connected-bucket dredges were operated also by the Merced Dredging Co. and the Snelling Gold Dredge Co., Snelling district, Merced County; by Thurman & Wright, Consumnes River district, and by the Capital Dredging Co. and the Rancha Plana Gold Dredging Co., Folsom district, Sacramento County; by the Thurman Gold Dredging Co., Redding district, Shasta County; by Yreka Gold Dredging Co., Klamath River district, and by the Junction

[1] Merrill, Charles White, U. S. Bur. Mines, Mineral Market Report M.M.S. No. 1577, Jan. 30, 1948.

Table 1. Mine production of gold in California during 1947, by counties

County	Mines producing[1]		Gold	
	Lode	Placer	Fine ounces	Value
Amador	8	11	4,724	$165,340
Butte	3	10	27,037	946,295
Calaveras	13	11	5,171	180,985
Colusa	1		6	210
El Dorado	13	12	2,994	104,790
Fresno	1	3	235	8,225
Humboldt		1	139	4,865
Inyo	41		1,974	69,090
Kern	16	6	6,228	217,980
Lassen	1		1	35
Los Angeles		4	48	1,680
Madera		4	197	6,895
Mariposa	15	5	6,363	222,705
Merced		3	16,422	574,770
Mono	2		41	1,435
Nevada	11	14	81,330	2,846,550
Placer	4	25	5,358	187,530
Plumas	4	7	546	19,110
Riverside	2	1	30	1,050
Sacramento		14	113,560	3,974,600
San Bernardino	24	2	4,409	154,315
San Diego	1		13	455
San Francisco		1	4	140
San Joaquin and Shasta[2]	6	7	18,256	638,960
Sierra	12	10	13,263	464,205
Siskiyou and Stanislaus[2]	9	24	39,141	1,369,935
Trinity	2	20	13,905	486,675
Tuolumne	19	5	4,232	148,120
Yuba	2	10	65,788	2,302,580
Total: 1947	210	210	431,415	$15,099,525

[1] Excludes itinerant prospectors, snipers, high-graders, and others who gave no evidence of legal right to property.

[2] Combined to avoid disclosure of individual output.

City Mining Co., Junction City district, Trinity County. An increasing number of placer operators used dragline equipment during 1947, but several failed to produce throughout the year. Several hydraulic operations were active during 1947, and gold was produced from the Morris Ravine drift mine, Oroville district, Butte County. Gold continued to be recovered in relatively minor quantity as a byproduct by several gravel companies.

"Gold production at lode mines remained about the same in 1947 as in 1946 and the general outlook for this class of gold mining was not a bright one. Not only did many former producers fail to reopen but several, including the Argonaut Mining Co., Ltd., stopped maintenance work entirely at their mines with a view toward a permanent shutdown. Increasing costs of mining resulting in inability to operate profitably was the reason for such action. In 1946, lode gold derived from gold ores accounted for 92 percent of the total lode gold produced, and 8 percent was recovered from gold-silver ore and ores mined primarily for copper, lead, zinc, and other base metals. Preliminary figures indicate that the ratio was about the same in 1947. Nearly two-thirds of the gold from gold ore produced in California in 1947 was mined in the Grass Valley-Nevada City district, Nevada County, almost entirely by the Idaho Maryland Mines Corporation and the Empire Star Mines Co., Ltd., the latter company operated its mine at Grass Valley under a leasing system and accepted gold ore and precipitates for treatment at the company mill from other mines on a custom basis. In the Washington district of Nevada County the Ancho-Erie Mining Co. was a substantial producer during 1947. In the Mother Lode Counties, the larger shipments of gold derived from gold ore were made by the Mount Gaines Mining Co., Hunter Valley district, Mariposa County, and the Eagle Shawmut Mine, Mother Lode district, Tuolumne County. The Eagle Shawmut mine was closed down permanently during the latter

part of the year and equipment was being sold. Burton Bros., Inc., cyanided gold ore from the Tropico mine, Mojave district, Kern County, and recovered a substantial quantity of gold. The Original Sixteen to One Mine, Inc., operated the Brush Creek mine, Downieville district, Sierra County, throughout the year. Of the mines that operated chiefly for base metal in 1947, only the Penn mine, Campo Seco district, Calaveras County, operated by the Shawmut Copper Mine Co., yielded more than 1,000 ounces of gold."

Gypsum (Crude). The gypsum output in California during 1947 totaled 811,798 short tons valued at $1,996,157. It came from seven properties in Kern County; two in Riverside County; and one property each in Fresno, Imperial, Kings, and Ventura Counties. The 1947 gypsum production was the largest in both quantity and value ever reported in this state. In 1946, production of 574,345 short tons of gypsum worth $1,315,699 was reported.

Most of the gypsum from Imperial and Riverside Counties was put to industrial uses and marketed in a manufactured form as plaster of paris and wall board; gypsum from Ventura County went into the manufacture of cement; and gypsum from Fresno, Kern, and Kings Counties, and a small quantity of Riverside County production went into agricultural uses as soil conditioner.

In California 490,268 short tons of gypsum was sold as an agricultural mineral in 1947.[2] This was a considerable increase over the 24,218 short tons produced in 1937.

Gypsum is used on the land to assist in granulating or breaking up heavy clay soils so that water can penetrate them and they may be more easily worked. Gypsum tends to neutralize alkali soils, and to convert sodium carbonate to sodium sulfate, which is less injurious to plant life. It also stimulates the decay of organic matter and supplies calcium and sulfur to the vegetation.

Iodine. California is the only state in the nation in which iodine is produced. The 1947 output was the largest so far reported. Four plants in Los Angeles County, operated by two separate companies, extract this mineral from the waste water produced by oil wells.

Iron Ore. Iron ore shipped during 1947 totaled 373,574 long tons from the Vulcan mine at Kelso and the Cave Canyon mine, both in San Bernardino County. It was reported that 226,062 long tons were shipped from these mines in 1946. The ore from the Vulcan mine went to the Kaiser Company's plant at Fontana to be reduced to pig iron and then made into steel. The ore from the Cave Canyon mine went to the Riverside Portland Cement Company's mill at Crestmore to be used in the manufacture of high iron cement.

In 1948 the Kaiser Company completed 51 miles of railroad from the Southern Pacific main line near Salton to the Eagle Mountain iron deposit in Riverside County, where production was under way in 1948. The Vulcan mine has been shut down.

Kyanite. In 1947 there was no kyanite production. In 1946, a small tonnage was shipped from a property near Ogilby, Imperial County. The kyanite produced in California was used in refractories and electrical insulators.

Lead. The lead produced in California during 1947 totaled 20,160,000 pounds worth $2,903,040; 1946 production was 19,846,000 pounds

[2] Fertilizing materials: California Dept. Agriculture, Special Pub. 227, 1947.

worth $2,163,214. Inyo County accounted for 17,980,000 pounds of the state's 1947 lead output. The Darwin mine at Darwin was the largest producer, and the Shoshone mines (Columbia No. 2) at Tecopa ranked second. Lead was also produced from Calaveras, El Dorado, Mono, San Bernardino, Shasta, and Sierra Counties during 1947.

The average price paid the miner for lead during the year 1947 was 14.4 cents a pound compared with the 1946 price of 10.9 cents. The November 11, 1948, quotation, New York, for refined lead is 21.5 cents per pound.

Lime. California sources produced during 1947 a total of 181,296 short tons of lime worth $2,615,599; during 1946 the output was 172,623 tons worth $2,144,712. The 1947 output of lime came from two plants in El Dorado, two plants in San Bernardino, and one plant each in Alameda, Monterey, and Tuolumne Counties.

During 1947 California agriculture [3] consumed 13,280 tons of by-product lime, 1,182 tons of hydrated lime, and 18,533 tons of limestone, shells, and marl as soil conditioners; as compared with the 1937 totals of 12,329 tons of by-product lime, 475 tons of hydrated lime, and 3,017 tons of limestone, shells, and marl. These materials are used on the soil to correct acidity, to assist in granulating or breaking up heavy clay soils, to promote decay of organic materials, and to assist in the formation of calcium nitrate. Pulverized limestone is also used as a diluent or admix in commercial fertilizers.

Lithium Minerals. Lithium-sodium phosphate was produced from the brines of Searles Lake in San Bernardino County during 1947 and was the chief source of lithium salts in the nation for the year.

Magnesite. During 1946 and 1947 the Westvaco Chemical Company shipped a small amount of crude magnesite from the Western Magnesite mine in Santa Clara County to their plant at Newark. It was mixed with magnesite from Nevada to make it meet the required specifications for certain refractory magnesium compounds.

Magnesium. No production was reported for 1947. During 1946 an output of 56 tons of magnesium worth $21,644 was made by the Permanente Metals Corporation at Permanente, Santa Clara County, in its carbothermic reduction plant in an experimental operation.

Magnesium Compounds (Natural). During 1947 a total of 40,000 short tons (MgO equivalent) of magnesium compounds worth $1,784,000 was produced; the 1946 total was 55,953 tons worth $2,814,979. Magnesium compounds were precipitated from sea water or from salt-works bitterns and came from three plants on San Francisco Bay, one on Monterey Bay, and one on San Diego Bay.

The plants at Newark, Alameda County, and Moss Landing, Monterey County, produce magnesium compounds for refractories and oxychloride cement; the plant at South San Francisco produces pharmaceutical-grade magnesium carbonates, hydroxide, and oxide; the plant at Redwood City, San Mateo County, makes magnesium carbonate for insulation; and the one near San Diego, San Diego County, produces magnesium chloride.

Mercury (Quicksilver). Mercury produced from California ore during 1947 totaled 17,165 flasks of 76 pounds worth $1,437,397, as com-

[3] Fertilizing materials: California Dept. Agriculture, Special Pub. 227, 1947.

pared with the 1946 total of 17,782 flasks worth $1,746,904. The 1947 output came from 25 properties located in Fresno, Lake, Napa, San Benito, San Luis Obispo, Santa Clara, and Yolo Counties. Approximately 90 percent was produced from three mines—the New Idria in San Benito County, the Mount Jackson in Sonoma County, and the Reed in Yolo County. In 1947 California accounted for approximately 75 percent of the nation's output of mercury.

Prices on mercury fell throughout the year and were the lowest since January 1939. The average price of mercury at New York for the year 1947 was $83.74 per flask compared with the 1946 price of $98.24 per flask. For the first 3 months of 1947 New York quotations averaged $87.24 per flask, and for the last quarter of the year they averaged $79.78.

Mica. During 1947 sericite mica was mined and shipped from a property near Ogilby, Imperial County, which has been operating almost continually since 1929. The material is ground and used for roofing paper, as a foundry facing, in stucco paint, and for decorative purposes to create the appearance of snow.

Mineral Water. Water from springs or artesian wells, bottled, in part artificially carbonated, and sold in 1947, was produced from properties in Butte, Calaveras, Contra Costa, Lake, Los Angeles, Marin, Napa, Orange, Riverside, San Benito, San Bernardino, San Diego, San Francisco, San Luis Obispo, Santa Barbara, Shasta, Siskiyou, Sonoma, and Tehama Counties. Health and pleasure resorts are located at many of the hot springs through the state. The water from some of the hot springs is not suitable for drinking but is excellent for baths.

Molybdenum Ore. Molybdenum concentrate has been made at the mill of United States Vanadium Corporation on Pine Creek, near Bishop, Inyo County, as a by-product from tungsten ore.

Natural Gas. Total value of natural gas production in California was second only to petroleum during 1947, and came from properties in 20 counties. The output was 544,950,000 M cu. ft. valued at $55,694,000 at the well, as compared with the 1946 total of 487,904,000 M cu. ft. worth $36,056,000.

The quantity and value of the 1947 output were the largest of any year so far reported for the state. The average amount received for natural gas at the well during 1947 was 11 cents per M cu. ft.; the 1946 price was 7.4 cents per M cu. ft.

Table 2. Natural gas production in California during 1947, by counties

County	M. cu. ft.	Value
Fresno	63,814,000	$6,750,000
Kern	86,289,000	8,329,000
Kings	39,972,000	4,282,000
Los Angeles	95,702,000	8,348,000
Orange	29,399,000	2,465,000
Sacramento	72,883,000	8,357,000
San Joaquin	9,650,000	1,261,000
Santa Barbara	18,070,000	1,317,000
Solano	65,411,000	8,155,000
Ventura	46,140,000	4,392,000
Butte, Contra Costa, Glenn, Humboldt, Madera, Stanislaus, Sutter, Tulare, Yolo	17,620,000	2,038,000
Totals	544,950,000	$55,694,000

Natural-gas gasoline produced during 1947 in plants operating in oil fields of Fresno, Kern, Kings, Los Angeles, Orange, Santa Barbara, and Ventura Counties, totaled 837,313,000 gallons valued at $45,812,000; the 1946 production was 734,227,000 gallons worth $32,085,000.

Liquefied petroleum gases produced during 1947 totaled 233,546,000 gallons worth $8,174,000, from plants in the same counties mentioned above as producing natural-gas gasoline. Total 1946 production was 176,311,000 gallons worth $4,933,000.

Peat. Peat is mined on the islands in the delta of the Sacramento and San Joaquin Rivers in Sacramento, San Joaquin, and Contra Costa Counties; from dry lakes in the northeast corner of the state in Modoc County; and from Orange and Santa Cruz Counties. The material is used as a soil amendment and mulch.

Pebbles for Grinding. Grinding-mill pebbles were produced in California during 1947 from the beach at Carlsbad, San Diego County.

Perlite. Several perlite-expanding plants are operating in California, but during 1947 they received all their crude perlite from out of the state. In 1948 shipments of crude perlite from Napa County were made to an expanding plant at Campbell. Crude perlite from a deposit near Big Pine, Inyo County, was shipped to plants in the Los Angeles area and to plants in the East. A small tonnage of crude perlite was also shipped from Modoc County. Deposits of perlite are known to exist in several counties, and probably more will be found in the near future.

Petroleum. California ranks second to Texas, among the states, in the quantity and value of its petroleum output. The 1947 output of crude oil was the largest ever produced in the state both in amount and value, and totaled 333,102,000 barrels worth $571,688,000. Petroleum accounted for approximately 67 percent of the value of the state's mineral output for 1947. In 1946, 314,713,000 barrels of petroleum, worth $387,100,000, was produced.

Table 3. Petroleum production in California during 1947, by counties

County	Barrels	Value
Fresno	44,133,000	$75,388,000
Kern	106,048,000	176,360,000
Kings	7,503,000	15,482,000
Los Angeles	91,889,000	164,122,000
Orange	34,146,000	58,274,000
Santa Barbara	22,463,000	33,221,000
Ventura	26,858,000	48,750,000
Monterey, San Bernardino, San Luis Obispo, Santa Clara	62,000	91,000
Totals	333,102,000	$571,688,000

Prices quoted on California crude oil during 1947, effective March 19, were increased 20 cents per barrel on all gravities, and on July 1 an additional 20 cents per barrel increase was granted; on October 28 a 10 cents per barrel increase on all gravities was made; on December 1 one oil company granted a 40 cents per barrel increase; and on December 27 all other crude oil purchasing companies made a 50 cents per barrel increase on all grades of petroleum. The price of all grades of petroleum in all fields through the state increased $1.00 per barrel during the year, and the heaviest gravity oils in Santa Barbara County more than doubled in price.

Phosphate Rock. No phosphate rock is mined in California, but a considerable amount of phosphate rock and super-phosphate is shipped into the state for making fertilizers. Before being sold to the farmer, most of the phosphate rock is converted into super-phosphate or thermo-phos. In the past a very small tonnage was used without treatment, but in 1947 no crude phosphate rock was sold as a soil conditioner. Two plants in the state, one at Richmond and the other at Vernon, manufacture super-phosphate; a plant at Permanente makes thermo-phos.

Platinum Metals. During 1946 and 1947 platinum-group metals were recovered in California by the gold dredges operating in Butte, Merced, Sacramento, and Yuba Counties. Much of the platinum produced during the 2 years was held by the mining companies and not sold. A large percentage of iridium and osmium, and lesser amounts of rhodium, palladium, and ruthenium are associated with the platinum recovered in this state.

Potash. Potash salts are recovered from the brines of Searles Lake, San Bernardino County, at the plant of the American Potash and Chemical Corporation. As a result of a recent increase in capacity of the plant, the 1947 output was the largest ever reported.

The potassium salts produced in the state are the sulfate and the chloride, which are used in commercial fertilizers. Potassium is one of the elements essential to plant life, and compared with most elements it is required in fairly large quantities.

Pumice and Pumicite. California led the nation in shipments of pumice and pumicite during 1947, with 169,037 short tons worth $1,026,275. The 1946 total was 89,181 short tons worth $755,570. The 1947 output came from properties in Amador, Calaveras, Contra Costa, Inyo, Kern, Madera, Modoc, Mono, Napa, Siskiyou, and Sonoma Counties. All was lump pumice except that from Amador and Kern Counties and one Madera County property. Most of the pumice was used in light-weight aggregate, chiefly in concrete blocks and acoustic plaster. A small portion was used as an abrasive in both pumice grits and scouring blocks. The pumicite was utilized as a scouring agent in cleanser, in soap, and as a carrier for insecticides.

Pyrite. For many years pyrite has been mined and shipped from the large massive Hornet mine deposit at Matheson, Shasta County. This material is shipped to two plants in the San Francisco Bay area and used in the manufacture of sulfuric acid. At one of these plants ore high in pyrite is roasted to produce sulfur-trioxide gas. The residue is shipped to a nearby smelter. A small amount of pyrrhotite from the Old Dominion mine in Orange County is being used as an agricultural mineral.

Salt. Salt is recovered by solar evaporation from the waters of San Francisco, Monterey, Newport, and San Diego Bays, and from dry lakes in Kern and San Bernardino Counties. Rock salt is mined from a property in San Bernardino County. During 1947 a total of 768,397 short tons of salt worth $3,810,898 was shipped from plants in the State. The 1946 total was 729,092 short tons worth $3,358,060. The material shipped during 1947 came from three properties in Alameda County; two in San Bernardino County; and one property each in Kern, Monterey, Orange, and San Diego Counties.

Sand and Gravel. A total of 31,386,826 short tons of sand and gravel valued at $25,338,967 was produced in California during 1947. It came

from properties in 53 counties. The 1946 total of 27,220,849 short tons, worth $18,396,460, came from 54 counties. California's output exceeds that of any other state. All counties have contributed at some time, although in several counties no output has been reported for a number of years. Included under this heading are molding sand and glass sand which came from properties in Contra Costa, Los Angeles, Monterey, Orange, Riverside, Sacramento, San Diego, San Mateo, and Ventura Counties.

Silica (Quartz). During 1947 vein quartz was shipped from single properties in Kern and Mariposa Counties; and ganister from one property in San Bernardino County. Most of the quartz was used in the manufacture of refractories.

Serpentine. In 1946 the Permanente Metals Corporation at Permanente, began to manufacture a fertilizer called thermo-phos in which serpentine produced near Almaden, Santa Clara County, and phosphate rock were fused.

Silver. Silver produced in California during 1947 totaled 1,597,442 fine ounces worth $1,445,685; the 1946 total was 1,342,651 fine ounces worth $1,084,862. The price fixed by the United States Treasury for newly mined silver during 1947 was $0.905; the 1946 price was $0.808; and the 1940-45 price was $0.7111.

Table 4. Mine production of silver in California during 1947, by counties

County	Mines producing[1]		Silver	
	Lode	Placer	Fine ounces	Value
Amador	8	11	11,598	$10,496
Butte	3	10	2,201	1,992
Calaveras	13	11	97,076	87,854
Colusa	1		3	3
El Dorado	13	12	2,039	1,845
Fresno	1	3	37	33
Humboldt		1	22	20
Inyo	41		1,235,998	1,118,578
Kern	16	6	7,686	6,956
Lassen	1		6	5
Los Angeles		4	6	5
Madera		4	57	52
Mariposa	15	5	1,933	1,749
Merced		3	1,505	1,362
Mono	2		7,323	6,627
Nevada	11	14	25,744	23,298
Placer	4	25	807	730
Plumas	4	7	570	516
Riverside	2	1	15	14
Sacramento		14	6,203	5,614
San Bernardino	24	2	103,877	94,009
San Diego	1		6	5
San Francisco		1		
San Joaquin and Shasta[2]	6	7	78,427	70,977
Sierra	12	10	2,501	2,263
Siskiyou and Stanislaus[2]	9	24	4,343	3,931
Trinity	2	20	1,677	1,518
Tuolumne	19	5	2,015	1,824
Yuba	2	10	3,767	3,409
Total: 1947	210	210	1,597,442	$1,445,685

[1] Excludes itinerant prospectors, snipers, high-graders, and others who gave no evidence of legal right to property.

[2] Combined to avoid disclosure of individual output.

Most of the silver produced in California is a by-product from the mining of gold, copper, lead, and zinc.

The following paragraph is quoted from Merrill:[4]

"California was the sixth largest silver producing state in 1947; its output rose 22 percent and was the largest since 1941. Three-fourths of the 1947 total was derived from argentiferous lead and zinc-lead ores. The principal producers of such ores were the Anaconda Copper Mining Co., operating the Darwin mines, Coso district, and the Shoshone mines (from July 1, 1947), Resting Springs district, Inyo County, and the Finley Co., which operated the Shoshone mines (Columbia No. 2) during the first half of 1947. Other large silver producers were: The Shawmut Copper Mine Co., Penn mine (closed July 1947), Campo Seco district, Calaveras County (zinc ore); Frank W. Royer, Kelly mine, Randsburg district, San Bernardino County (gold-silver ore); Louis Warnken, Jr., operating in the Calico district, San Bernardino County; and the Mountain Copper Co., Ltd., Hornet Mine (closed June 1947), Flat Creek district, Shasta County, (zinc-copper ore). Much of the remainder of the silver produced in California during 1947 was derived from other base-metal ores."

Slate. Slate mined in California during 1947 came from properties in El Dorado, Mariposa, Placer, and Tuolumne Counties. Slate produced in El Dorado and Inyo Counties was used for roofing granules, for slate flour for fillers in linoleum, and for plastics. The remainder was sold for flagstone and stepping stones.

Sodium Salts. California is the chief source of natural sodium salts in the nation. Soda ash, trona, and salt cake were produced during 1947 from three properties on Owens Lake, Inyo County, and two properties on Searles Lake, San Bernardino County. The production from Owens Lake was chiefly soda ash with a small amount of trona; the production from San Bernardino County consisted of about equal amounts of soda ash and salt cake. The quantity and value of the 1947 output were the largest so far reported in the state. Reported during the year were 293,051 short tons of soda ash and trona worth $5,862,178.

Stone. Stone includes granite, limestone, sandstone, crushed rock, rubble and riprap. It was quarried in 47 California counties during 1947 and totaled 12,757,790 short tons worth $13,012,556; the 1946 total was 8,950,320 short tons worth $8,452,083. Granite—chiefly monumental stone—is produced from quarries in Fresno, Lassen, Placer, Riverside, San Bernardino, and San Diego Counties. Limestone used for burnt lime, in sugar refining, in metallurgical and chemical plants, as a soil conditioner, in poultry grits and stock feed, and in treating water, came from properties in El Dorado, Fresno, Inyo, San Bernardino, San Mateo, Santa Clara, Santa Cruz, Tuolumne, and Ventura Counties. The production from San Mateo County and part of the production from Santa Clara County consisted of shells dredged from San Francisco Bay. A small amount of sandstone was quarried and sold as flagstone, or was used in garden walls, barbeque pits, fire places, and in Spanish- and English-type houses for effect. This production came from Monterey, Napa, and Santa Barbara Counties.

Crushed rock, rubble, and riprap have been quarried from properties in every county of the state at one time or another. Heavy construction such as dams, reservoirs, air fields, and highways, greatly stimulate the production of these materials.

Strontium Minerals. Celestite and strontianite were mined in California from 1939-46, from properties in Imperial and San Bernardino Counties. No shipments were reported in 1947.

[4] Merrill, Charles White, Mine Production of Silver in the United States: U. S. Bur. Mines, Mineral Market Rep. 1578, Feb. 7, 1948.

Sulfur. During 1947 shipments totaling 698 long tons of sulfur worth $9,074 were made from a property in Inyo County; the 1946 total was 757 long tons worth $11,835. In Alpine County development work was done on a sulfur property and shipments were expected to start in 1948. Soil sulfur [5] amounting to 23,519 tons was sold in California during 1947, as compared with the 1937 sale of 2,517 tons. Nearly all the soil sulfur sold in the state was brought in from other states. It was used to increase acidity of alkaline soils. Where soils contain sulfur, the vegetation is much greener than otherwise. Sulfur is also said to modify bacteria in the soil. Sulfur in the form of sulfuric acid is used in the manufacture of many commercial fertilizers. Sulfur is also used as a fungicide in many agricultural sprays and dusts.

Talc, Pyrophyllite, and Soapstone. During 1947 California shipped 91,537 short tons of talc, pyrophyllite, and soapstone worth $1,595,422, as compared with the 1946 total of 78,170 tons worth $1,434,978. The materials mined in 1947 were talc from properties in Inyo and San Bernardino Counties; pyrophyllite from properties in Mono and San Diego Counties; and soapstone from properties in El Dorado and Tuolumne Counties.

Titanium Minerals. Titaniferous magnetite containing ilmenite was mined and shipped from Sand Canyon, Los Angeles County, during 1947. Part of this material was used as granules on prepared roofing material; the remainder went to a new pilot plant built to manufacture titanium pigments.

Tungsten Concentrates. During 1947 there were reported shipped in California 394 short tons of 60 percent WO_3 tungsten concentrates worth $548,233. The 1946 total was 1,262 short tons of 60 percent WO_3 concentrates worth $1,117,855. Material shipped during the year came from properties in Alpine, Fresno, Inyo, Kern, Madera, Mono, San Bernardino, and Tulare Counties.

Zinc. The recoverable zinc produced in California during 1947 amounted to 10,830,000 pounds worth $1,310,430; the 1946 total was 13,754,000 pounds worth $1,677,988. The 1947 output came from copper-zinc mines in Calaveras, El Dorado, and Shasta Counties; and lead-zinc mines in Inyo and San Bernardino Counties. All the copper-zinc mines in the state suspended operations on or before July 1, 1947.

The average price of prime western grade slab zinc for 1947, East St. Louis, was 10.5 cents per pound; compared with average weighted value of 11.7 cents per pound in 1946, including United States Government premium. Present quotation (December 22, 1948) East St. Louis, is 17.5 cents per pound.

CONTRIBUTIONS OF THE COUNTIES TO THE MINERAL PRODUCTION OF CALIFORNIA

The State of California has a population of 10,264,400 [6] and a total area of 158,297 square miles. The latter comprises a land area of 156,803 square miles and a water area of 1494 square miles, divided into 58 counties. The smallest county, San Francisco, contains an area of 45 square miles; the largest county, San Bernardino, contains an area of

[5] Fertilizing materials: California Dept. Agriculture, Special Pub. 227, 1947.

[6] State Chamber of Commerce, personal communication, January, 1949 . . . U. S. Dept. of Commerce, Bur. Census, 16th Census of the U. S., Population California, 1st series, 1941.

Table 5. Quantity and value of mineral substances produced in California during 1946 and 1947

The following figures for both 1946 and 1947 are supplied by the United States Bureau of Mines, with which the California State Division of Mines has a cooperative agreement for the collection of these statistics, starting with the year 1947.

Mineral product		1946		1947	
		Quantity	Value	Quantity	Value
Arsenious oxide	short tons	[2]	[2]	[2]	[2]
Asbestos	do	[1]	[1]	[1]	[1]
Asphalt (native)	do	[1]	[1]	[1]	[1]
Barite	do	[1]	[1]	[1]	[1]
Boron minerals	do	430,689	$9,575,866	501,935	$11,844,108
Bromine	pounds	[1]	[1]	[1]	[1]
Calcite (Iceland spar)	do	[3]	[3]	[3]	[3]
Calcium chloride	short tons	9,979	170,994	7,968	111,950
Cement	barrels	20,173,231	33,906,675	22,846,458	46,539,749
Chromite	short tons	[1]	[1]	948	[1]
Clay:					
Products heavy clay (other than pottery and refractories)			[4]12,175,000		[4]16,793,000
Raw	short tons	[5]1,670,305	[5]2,254,164	[5]1,950,076	[5]2,965,360
Coke	do	260,470	[1, 6]	332,244	[1, 6]
Copper	pounds	8,480,000	1,373,760	4,814,000	1,010,940
Diatomite	short tons	[1]	[1]	[1]	[1]
Feldspar (crude)	long tons			[1]	[1]
Ferro-alloys	short tons	7,414	[1, 6]	5,278	[1, 6]
Fullers earth	do	[1]	[1]	[1]	[1]
Gem stones			[3]		[3]
Gold	troy ounces	356,824	12,488,840	431,415	15,099,525
Gypsum (crude)	short tons	574,345	1,315,699	811,798	1,996,157
Iodine	pounds	[1]	[1]	[1]	[1]
Iron:					
Ore	long tons	226,062	[1]	373,574	[1]
Pig	short tons	344,024	[1, 6]	453,376	[1, 6]
Kyanite	do	[1]	[1]		
Lead	do	9,923	2,163,214	10,080	2,903,040
Lime	do	172,623	2,144,712	181,296	2,615,599
Lithium minerals	do	[1]	[1]	[1]	[1]
Magnesite	do	[1]	[1]	[1]	[1]
Magnesium	do	56	21,664		
Magnesium compounds (from sea water)[7]	short tons MgO equivalent	55,953	2,814,979	40,000	1,784,000
Mercury	flasks (76 pounds)	17,782	1,746,904	17,165	1,437,397
Mica, scrap	short tons	[1]	[1]	[1]	[1]
Mineral waters	gallons sold	[3]	[3]	[3]	[3]
Molybdenum	pounds	[1]	[1]	[1]	[1]
Natural gas (estimated value at wells)	M cu. ft.	487,904,000	36,056,000	544,950,000	55,694,000
Natural gasoline and allied products:					
Natural gasoline and cycle products	gallons	734,227,000	32,085,000	837,313,000	45,812,000
Liquefied petroleum gases	do	176,311,000	4,933,000	233,546,000	8,174,000
Ores (crude) etc.:					
Copper	short tons	86,297	[8]	15,993	[8]
Dry and siliceous (gold and silver)	short tons	335,657	[8]	449,792	[8]
Lead	do	57,330	[8]	87,913	[8]
Zinc	do	45,043	[8]	49,651	[8]
Zinc-copper	do	99,176	[8]	35,745	[8]
Zinc-lead	do	4,264	[8]	9,695	[8]
Peat	do	8,137	105,242	[1]	[1]
Pebbles for grinding	do	74	927	[1]	[1]
Petroleum	barrels	314,713,000	387,100,000	333,102,000	571,688,000
Platinum metals (crude)	troy ounces	67	[1]	324	[1]
Potassium salts	short tons	[1]	[1]	[1]	[1]
Pumice	do	89,181	755,570	169,037	1,026,275
Pyrites	long tons	[1]	[1]	[1]	[1]

Table 5. Quantity and value of mineral substances produced in California during 1946 and 1947—Continued

Mineral product		1946		1947	
		Quantity	Value	Quantity	Value
Salt (sodium chloride)	short tons	729,092	3,358,060	768,397	3,810,898
Sand and gravel	do	27,220,849	18,396,460	31,386,826	25,338,967
Sand and sandstone (ground)	do	[1]	[1]	[1]	[1]
Silica (quartz)	do	[1]	[1]	[1]	[1]
Silver	troy ounces	1,342,651	1,084,862	1,597,442	1,445,685
Slate			[1]		[1]
Sodium carbonate (natural)	short tons	[1]	[1]	293,051	5,862,178
Sodium sulfate (natural)	short tons	[1]	[1]	[1]	[1]
Stone	do	[9]8,950,320	[9]8,452,083	[9]12,757,790	[9]13,012,556
Strontium minerals	do	243	3,726		
Sulfuric acid (60° B.)[10]	do	[1, 6]	[1, 6]	[1, 6]	[1, 6]
Sulfur ore	long tons	757	11,835	698	9,074
Talc, pyrophyllite, and ground soapstone	short tons	78,170	1,434,978	91,537	1,595,422
Tungsten concentrates (60 percent WO_3 basis)	do	1,262	1,117,855	394	548,233
Zinc	do	6,877	1,677,988	5,415	1,310,430
Miscellaneous[11]			25,336,529		29,565,251
Total value, eliminating duplications (rounded figures)			592,294,000		855,553,000

[1] Value included with "Miscellaneous."
[2] Figure not available.
[3] No canvass.
[4] Figures obtained through cooperation with Bureau of the Census.
[5] Sold or used; value of clay used in cement and heavy clay products is included here but is not included in total value for state.
[6] Value not included in total value for state.
[7] Comprises all compounds from raw sea water and bitterns. Data for 1945-46 are not quite comparable with 1947 in that the former are on a gross-weight basis and include some compounds made from dolomite in combination with sea water.
[8] Not valued as ore; value of recoverable metal content included with the metals.
[9] Exclusive of marble, value for which is included with "Miscellaneous."
[10] From lead smelting.
[11] Includes minerals indicated by "1" and "9", above.

20,131 square miles. Production of commercial minerals during 1947 was reported from every one of the 58 counties.

The presence of numerous large oil fields within the boundaries of Kern, Los Angeles, Fresno, Orange, Ventura, and Santa Barbara Counties, and the resultant production of petroleum and natural gas, have placed these counties at the top of the list in value of mineral production. San Bernardino County occupies seventh place owing to the production of large quantities of cement, borates, potash, and soda. Production from the famous Kettleman Hills oil field and the Rio Vista gas field has placed Kings and Sacramento Counties in eighth and ninth places, respectively. Santa Clara County, in tenth place, is the locus of the largest cement mill in the world.

Mineral production values in excess of a million dollars have been reported from 31 counties in 1947. Million-dollar production values were also recorded by one or more counties in 1947 for each of the following minerals: boron minerals, cement, diatomite, gold, iron ore, lead, natural gas, petroleum, potassium minerals, salt, sand and gravel, silver, sodium minerals, and stone.

San Bernardino County produced 22 different minerals in 1947 surpassing all counties in variety of mineral products. Diversification of products in other counties was reported as follows: Inyo, 18 minerals; Kern, 14 minerals; Los Angeles, 13 minerals; and Fresno, 12 minerals.

*Table 6. Mineral production of California during 1947, by counties**

County	Value	County	Value
Alameda	$8,497,176	Plumas	$261,100
Alpine	(1)	Riverside	8,381,215
Amador	913,189	Sacramento	14,103,144
Butte	1,311,410	San Benito	2,497,069
Calaveras	4,199,321	San Bernardino	36,699,909
Colusa	89,963	San Diego	1,882,394
Contra Costa	1,388,682	San Francisco	(3)
Del Norte	322,156	San Joaquin	2,932,420
El Dorado	1,641,020	San Luis Obispo	396,393
Fresno	89,342,311	San Mateo	5,334,024
Glenn	[2]383,043	Santa Barbara	40,544,339
Humboldt	316,364	Santa Clara	11,981,146
Imperial	907,843	Santa Cruz	3,216,500
Inyo	6,596,468	Shasta	2,271,226
Kern	208,445,916	Sierra	468,196
Kings	24,601,000	Siskiyou	1,170,971
Lake	107,232	Solano	8,302,751
Lassen	71,828	Sonoma	1,050,051
Los Angeles	202,764,633	Stanislaus	1,112,357
Madera	237,072	Sutter	110,789
Marin	461,179	Tehama	(2)
Mariposa	301,938	Trinity	561,555
Mendocino	[3]528,181	Tulare	1,500,551
Merced	742,366	Tuolumne	901,067
Modoc	116,170	Ventura	62,514,862
Mono	332,893	Yolo	261,428
Monterey	2,602,297	Yuba	2,559,132
Napa	359,911	Heavy clay products (not entirely separable by counties[4])	15,605,828
Nevada	[3]3,008,304		
Orange	67,854,831		
Placer	487,751	State total (rounded)	855,553,000

* These figures are furnished by the United States Bureau of Mines in cooperation with the California State Division of Mines.

[1] Output of Alpine County is included with Nevada County.

[2] Output of Tehama County is included with Glenn County.

[3] Output of San Francisco County is included with Mendocino County.

[4] Figure shown represents value of heavy clay products (other than pottery and refractories) as reported by U. S. Bureau of the Census ($16,793,000), less value of raw clay sold or used for the manufacture of cement and heavy clay products ($1,187,172).

4—1932



HARVESTING SALT
Leslie Salt Company, Mt. Eden plant, Alameda County



CALIFORNIA POTTERY COMPANY
Niles plant, Alameda County



DARWIN HILLS
Lead mining camp of Darwin in center, Inyo County



A, LONG BEACH SALT COMPANY, KERN COUNTY



B, PACIFIC COAST BORAX COMPANY, KERN COUNTY



A, MONOLITH PORTLAND CEMENT COMPANY, KERN COUNTY



B, CLOSE-UP OF LOADER MINING GYPSITE
Holloway gypsum deposit, Kern County



EAGLE MOUNTAINS IRON MINE, RIVERSIDE COUNTY



LOADING LIMESTONE FOR SUGAR-BEET INDUSTRY
Essential Industries Inc., San Luis Obispo County



CORONADO COPPER AND ZINC COMPANY, SHASTA COUNTY

PART 2

MINERAL RESOURCES OF THE COUNTIES OF CALIFORNIA

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ALAMEDA COUNTY

General Geologic Features. Alameda is one of the central Coast Range counties, lying on the eastern shore of San Francisco Bay. It contains a land area of 733 square miles and supported a population of 735,000 in 1947. A northwest-trending alluvial plain of Quaternary age, 3 to 8 miles in width, constitutes the west border of the county. This plain rises from the tidal waters of the bay to an elevation of about 100 feet at its eastern inner margin. Here the Hayward fault, a persistent zone of structural weakness, separates the plain from the uplifted Berkeley Hills on the east. This is the dominant range in the uplifted block between the bay and Mount Diablo in Contra Costa County. Along its southwest flank the Franciscan formation of Jurassic age, composed of sandstones, shales, cherts, schists, and associated basic intrusives of peridotite altered to serpentine, is exposed. These rocks are overlain unconformably by Cretaceous sandstones and shales which extend over the summit of the range east of Hayward. The general dip of the Cretaceous sediments is northeastward, and they are flanked on the east by strips of upper and middle Miocene marine sediments forming the west limb of a syncline. The Miocene is in places covered by Pliocene sediments of continental origin interbedded with volcanic flows.

The headwaters of Arroyo Mocho, Arroyo Valle, and Alameda Creek, which form the principal drainage system of the county, are located in the southeastern part, where the maximum elevation, about 3,800 feet, is attained. Surface exposures are rocks of the Franciscan formation,

which cover about 110 square miles. The streams flow northwestward to the Livermore Valley, which covers about 70 square miles in the north-central part of the county; thence westward through Niles canyon and across the alluvial plain, from which they discharge into the bay at Alvarado. The Franciscan-covered area slopes northwestward and is overlain by Quaternary-Pliocene gravels in the low hills which form the south border of the Livermore Valley.

The Livermore Valley is bordered on the north by the southern tip of the Mount Diablo foothills where volcanic rocks of Pliocene age are exposed. It is closed on the east by the Altamont Hills along whose western base a probable fault has been mapped.[7]

The surface near Altamont is covered by marine sandstones and shales of upper Cretaceous age which are anticlinal in structure. South of Township 2 South, the Cretaceous is overlain by upper Miocene marine sediments over a wide area, through which the Cretaceous occasionally appears in fault contact. The Miocene near Tesla is flanked on the south by a thin strip of upper Eocene marine sediments. On the west the Livermore Valley is bounded by the Berkeley Hills, along whose eastern base the Calaveras fault has been mapped.

Mineral Resources. Large resources of salines, sand, gravel, pottery clay, brick clay, and miscellaneous stone exist in Alameda County. Sodium chloride (the salt of daily usage) is the principal saline product, and is obtained by solar evaporation of sea water along the eastern shore of San Francisco Bay in the vicinity of Newark. Bitterns from the salt plants are the source of magnesium compounds. The production of magnesium compounds from sea water has largely replaced the use of magnesite as a source material for these products. Additional by-products of salt production are bromine and potash. Clay obtained from Quaternary deposits of the Niles alluvial cone provides the raw material for ceramic and brick-making plants in the county. Small amounts of high-grade clays have been produced intermittently from the steeply dipping Eocene beds near Tesla. The excavation of sand and gravel from Quaternary deposits at Niles and from Quaternary-Pliocene deposits in the Livermore Valley constitutes an important phase of the mineral industry of Alameda County. In addition, numerous quarries for the production of crushed rock are distributed throughout the Berkeley Hills from central Oakland to Niles. Most of these quarries are located in the cherts and metamorphosed sandstone of the Franciscan formation. A small amount of chromite was produced at Cedar Mountain during the first world war. Coal classed as sub-bituminous was produced from the steep-dipping Eocene beds near Tesla. Over a 6-year period beginning in 1897 production averaged 70,000 tons annually. There has been practically no production of coal since 1902. Deposits of manganese associated with the cherts of the Franciscan formation southwest of Livermore produced small quantities of ore prior to and during World War I. A small quantity of manganese ore was also produced during World War II. A moderate amount of pyrite was produced annually from 1901-34. The pyrite occurred at Leona Heights in a narrow belt of rhyolite which extends through the hills from Berkeley to Decoto. The following commercial minerals are known to occur in Alameda County and production in small quantities has been reported: magnesite, limestone (bay shells), glass

[7] Huey, A. S., Geology of the Tesla quadrangle, California: California Div. Mines Bull. 140, 1948.

sand, asphalt, mineral paint, asbestos, travertine, soapstone, copper, lead, silver, and gold.[8]

Significant Activities During 1947. Clays from the Livermore Valley and from the Niles alluvial cone have been used for many years in the manufacture of sewer pipe, roofing tile, structural shapes, and other clay products. To obtain a working medium with the desired properties, the local clays are usually blended with other clays "imported" from Calaveras and Amador Counties.

Sea-water bitterns from nearby salt ponds are used at the Newark plant of the Westvaco Chemical Corporation in the manufacture of basic magnesium carbonate. This company also produces bromine in an adjoining plant.

Common salt, sodium chloride, is the chief saline product in Alameda County. It is obtained by solar evaporation of the waters of San Francisco Bay. Large quantities of water are pumped from the bay into intake ponds where the evaporation process begins. As the gravity of the solution increases it is moved along into concentrating ponds, and finally transferred into crystallizing ponds where the salt crystallizes out in a bed about 5 inches thick. About 2 years are required to complete the cycle. The ponds of the Leslie Salt Company cover an area of about 25,000 acres, fringing the southern end of San Francisco Bay. The actual deposition and harvesting of the annual salt crop occurs at Newark and Mount Eden in Alameda County. The bed of salt is recovered by mechanical harvesting machines having a capacity of 125 tons per hour. These machines load trains composed of twelve 2-ton bottom-dump cars powered by 4-ton Vulcan gasoline locomotives running on lightweight movable narrow-gauge tracks. The salt is hauled to central washing plants, scrubbed in salt water to remove clay or dirt, and conveyed to the crude-salt storage pile. In the adjoining refinery, salt for human consumption is processed to the highest degree of purity in triple-effect evaporators.

A small amount of naturally bonded moulding sand is produced from a steep-dipping 15-foot bed near the old Tesla coal mine. This sand is about 70 percent sand and 30 percent clay and is mined by underground methods. The crude material is run through a hammer mill, delivered to consumers, and used in synthetic facings for medium and heavy iron work.

Stone for concrete aggregate, road surfacing, and fill material constitutes the largest item of mineral production in Alameda County. Numerous sand and gravel plants are located in the Livermore Valley and on the Niles alluvial cone. Caterpillar-mounted dragline excavators are usually employed to mine the gravel from open pits. This gravel is transported by trucks or belt-conveyor systems to nearby washing and screening plants where the pit-run gravel is crushed, washed, and graded to sizes suitable for concrete aggregate. At the crushed-rock quarries the bank-run material is shovel-loaded to trucks, transported to crushing plants, reduced, and sized. Some of the crushed rock products are washed, although washing is not required on road and fill material.

F.F.D.

[8] Laizure, C. McK, San Francisco field division—Alameda County: California Div. Mines Rept. 25, pp. 427-456, 1929.

Table 7. Mineral production from Alameda County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[1]$1,165,000
Clay, raw	18,751 short tons	18,782
Salt (sodium chloride)	540,943 short tons	3,046,907
Sand and gravel	3,844,057 short tons	3,578,314
Stone	1,112,500 short tons	714,025
Unapportioned (bromine, lime, crude magnesite, and magnesium compounds		1,139,148
Total value		$8,497,176

[1] According to U. S. Bureau of the Census; value not included in county total.

ALPINE COUNTY

General Geologic Features. Alpine County, located along the eastern border of central California, a few miles south of Lake Tahoe, is an area of mountain peaks and ridges, cut by a few deep valleys. Maximum elevations are in the southeastern corner of the county, where Stanislaus Peak and White Mountain stand over 11,000 feet above sea level.

The western part of the county is occupied almost entirely by the granitic rocks of the Sierra Nevada batholith, and the western boundary of the county parallels the north trending crest of California's dominant mountain range. The Jurassic intrusives in the area are strongly fissured and jointed in contrast to the granitic rocks of the western slopes.[9] Rocks of the western part of the county show ample evidence of the numerous glaciers which occupied present drainage areas in late Pleistocene time.[10]

Tertiary volcanics, essentially andesite, blanket a large portion of the eastern half of Alpine County and extend into neighboring Nevada. A few isolated patches of these volcanics are found in the western half. Silicification of the volcanics and resulting mineral deposition is pronounced in several sections, particularly in the area southeast of Markleville.[11] A few small outcrops of pre-Cretaceous metamorphics, including slates, schists, limestone, greenstone, and conglomerate are widely scattered throughout the county. They are embedded in the granite or granodiorite and have suffered regional and contact metamorphism.[12]

Drainage of this high Sierra country is mainly through the East and West Forks of the Carson River and their many tributaries. The East Fork rises in the south-central portion of the county and flows northward through the main volcanic-rock area into Carson Valley. The West Fork rises in the west-central part, flows northward, thence eastward into the adjoining state. Headwaters of the Stanislaus and Mokelumne Rivers drain the southwestern area.

Grover's Hot Springs are situated near the southern terminus of a major fault which strikes northward and passes near Woodfords. Numerous large hot springs are located on this fissure along its northerly extension in Nevada. Where the escarpment crosses the West Fork of the Carson River, the gradient of the stream increases markedly downstream.

[9] Lindgren, Waldemar, The Tertiary gravels of the Sierra Nevada of California: U. S. Geol. Survey Prof. Paper 73, 226 pp., maps, 1911.

[10] Blackwelder, Eliot, Glacial and associated stream deposits of the Sierra Nevada: California Div. Mines Rept. 28, pp. 303-310, 1932.

[11] Eakle, A.S., et al., Alpine County: California Min. Bur. Rept. 15, pp. 5-27, 1919.

[12] Lindgren, W., op. cit.

Mineral Resources. In spite of the variety of mineral occurrences which have been reported in Alpine County, including copper, lead, zinc, gold, silver, quicksilver, molybdenum, tungsten, limestone, miscellaneous stone and sulphur, production has been small. There are no important deposits of auriferous gravels. During the period of recorded mineral production from 1880-1947, the total value was less than $400,000. Prior to 1880 an estimated $1,000,000 in gold and silver was produced from the county. This period of productivity paralleled the Comstock Lode activity. Alpine County contributed heavily to the development of the Comstock Lode by furnishing mine timbers and fuel from its abundantly forested mountains.

The most important mineralized area of the county is a few miles south and southeast of Markleeville, centering around the Mogul, Monitor, and Silver Mountain districts. Here the andesite has been extremely altered and silicified by ascending thermal waters. Subsequently complex ores of gold, silver, lead, zinc and copper were deposited. Sulphur in commercial quantities is found in the Leviathan mine, originally opened as a copper property, in the northeastern section of the mineralized area. The complex nature of the low-grade ores made beneficiation difficult in the early days and contributed to the decline in production. Some high-grade spots were encountered in the ore bodies, most of which were without definite walls, being impregnated masses of the altered andesite. No great depth was reached in the operations; a great deal of the prospecting and development work was done through adits.

In the Silver King district, 15 miles south of Monitor, auriferous pyrite occurs in a section of metamorphosed rocks (schists). Ten miles west of Markleeville, in the Blue Lakes and Hope Valley region, metamorphosed sediments have been mined for gold, silver, copper, and tungsten. The latter occur in the contact-metamorphic ore bodies (tactite) in limestone in the Hope Valley section. Epithermal hübnerite (manganese tungstate) has been found in the ore of the Zaca mine (silver) near Monitor.[13]

Significant Activities During 1947. The mineral materials produced in Alpine County during 1947 were confined to tungsten and miscellaneous stone (sand and gravel). The Alpine Mining Company (Wolframite mine) operated their tungsten deposit 3 miles north of Carson Pass in Hope Valley during the year. The ore was hauled to Minden, Nevada for concentration. At the Leviathan mine (copper-sulphur), the Siskon Mining Company continued rehabilitation of the mine workings. There was no production of gold and silver reported for the year. L.A.N.

AMADOR COUNTY

Geologic Features. Amador County is bounded by the South Fork of Cosumnes River on the north and Mokelumne River on the south. The land rises gradually from the eastern border of Sacramento Valley on the west to the western summit of the Sierra Nevada. Most of the streams flow southwest and are tributaries of Mokelumne River.

Extending northwest across the westernmost part of the county are Eocene sedimentary beds which are economically important because of the clay and lignite deposits found in them. These beds dip slightly to

[13] Gianella, Vincent, Epithermal hübnerite in the Zaca mine, Alpine County, California: Econ. Geology, vol. 33, no. 3, May 1948.

the west and cover the lower western bedrock slope which consists of a complex of amphibolite schist, Jurassic slate, and Carboniferous slate and schist. These tightly compressed and metamorphosed basement rocks strike uniformly northwest, dip steeply northeast and outcrop in a belt 8 miles wide. Some copper ore occurs in the amphibolite schist in the western part of the belt and the Carboniferous members contain many small deposits of high-calcium limestone. Along the east border of this complex, a band of greenstone (meta-andesite) is in contact with the Jurassic clay slate of the Mother Lode. The slate and contact zone is traversed in a northwesterly direction by the Mother Lode reverse fault. The 10 miles of this fault zone which crosses Amador County has been most important in gold production. For 10 miles or more east of the Mother Lode the exposed rocks are principally the Carboniferous (Mississippian) series of hard slate, schists and quartzite, penetrated in only a few places by outliers of the Sierra Nevada batholith, and capped here and there by remnants of volcanic debris which followed ancient stream courses flowing from the mountains which lie to the east. The most important deposits here are large beds of limestone, mostly undeveloped, at Volcano and near Fiddletown. Numerous small gold mines occur in the Carboniferous rocks and in the western part of the granitic batholith which adjoins them on the east. This is the East Belt, in which the ore bodies are smaller and ore more complex but frequently richer than in the Mother Lode.

Mineral Resources. Amador County has been noted for its Mother Lode deposits of gold ore, which have been worked to a vertical depth of more than a mile below the surface. The lode-gold production of the Amador County has been second in California only to that of Nevada County.

Next in importance are the clay deposits of the Ione and Carbondale districts, where both open pits and underground mines have supplied for years a variety of clays from the Ione (Eocene) beds. Part of the clay is highly refractory. One pottery is in operation in the county, but clay is shipped to many other plants in different parts of the state.

Lignite was mined for many years prior to 1902 from deposits associated with the Ione clay. Two lignite deposits are now being reopened. Limestone and marble are plentiful and have been produced in years past. Miscellaneous stone is produced for local use. Other minerals produced in the past include asbestos, copper and copper ores, chromite, gem minerals (diamonds and chrysopal), manganese ores, by-product platinum, lead and silver (from gold and copper mining), soapstone, silica sand, sandstone, and slate. Rock wool has been produced the past few years from old copper smelter slag.

Significant Activities During 1947. The continued increase in labor and material costs has hampered resumption of gold-lode mining and prevented reopening of several mines. The Central Eureka mine at Sutter Creek was being rehabilitated during 1947. The Belden mine on the East Belt was the most important producer among the small mines in that region, where ores are in some cases rich enough to permit work even at present high costs. The Argonaut mine management has decided to dissolve the company because of present unfavorable conditions, and not due to the exhaustion of ore. In 50 years of operation, this mine produced more than $25,000,000 and paid $3,789,750 in dividends on

a capitalization of $1,000,000. The deepest level, at 6,300 feet inclined depth, is 5,570 feet vertically below the shaft collar, or 4,000 feet below sea-level. The Argonaut is the second deepest mine in the state, being surpassed only by its neighbor the Kennedy, which is also closed.

Mining and shipment of copper ore from the Newton mine near Ione ended with the expiration in mid-year of the bonus paid by the United States Government. Clay production continued at a good rate. A new plant was completed by De Angelis Coal Company at the Buena Vista lignite mine, and experimental work started late in 1947 on the production of montan wax, mineral pigments, and briquettes from lignite mined at that property and another deposit near Ione. C.A.L.

Table 8. Mineral production from Amador County during 1947

Product	Quantity	Value
Clay, raw	198,264 short tons	$380,496
Copper	1,674,000 pounds	351,540
Gold	4,724 troy ounces	165,340
Silver	11,598 troy ounces	10,496
Unapportioned (pumice, sand and gravel, and stone)		5,317
Total value		913,189

BUTTE COUNTY

Geologic Features. Butte County lies at the junction of three major California geomorphic provinces. The southern terminus of the volcanic Cascade Range is near the northern border of the county; the western half of the county is part of the Great Valley; and the eastern half is within the northern Sierra Nevada. The rocks of Butte County may be divided roughly into two major groups and eight sub-groups. The subjacent or bedrock series consists largely of metasediments and metavolcanics of pre-Cretaceous age, and serpentine and granitic rocks intrusive into them. The Superjacent or overlying series consists of Pleistocene and Recent alluvium, late Tertiary volcanics (chiefly basalt and andesite), early Tertiary sediment, and Upper Cretaceous sediments. Rocks of the Superjacent series lie unconformably upon the folded bedrock surface.

The Great Valley in Butte County presents, for the most part, exposures of Pleistocene and Recent alluvium, but narrow outcroppings of the underlying Cretaceous and Eocene sediments are exposed along major water courses at the eastern edge of the valley where they lap up onto the tilted bedrock surface of the main mass of the Sierra.

In the Sierran foothills, the bedrock metavolcanic greenstones and the metasediments trend roughly northwest, the structure being disrupted in many places by large intrusions of serpentine and still larger ones of granitic rocks. An excellent section of basement rocks is exposed along the North Fork of the Feather River. Leaving Oroville, Highway 24 passes successively through a broad belt of metavolcanic greenstones, Calaveras (?) slate, a small body of serpentine, more greenstone, a large body of serpentine, and finally into granodiorite. Small limestone lenses appear in the metasediments at some points.

Andesites and basalts of the Cascade province cover the bedrock in the extreme northeastern part of Butte County and rhyolite tuff of the

Pliocene Tuscan formation underlies the volcanics at some points. The Tuscan formation interdigitates with the sediments of the Tehama formation under the Great Valley.

Strike faulting largely of thrust type disrupts the bedrock structures in some parts of the county, but to date no great system such as is known in the Mother Lode region has been described in the northern Sierra Nevada. Normal faults that cut the Tertiary and Quaternary volcanics have been described.

Mineral Resources. The principal mineral resources of Butte County are gold, miscellaneous stone, and crystalline limestone. The first two were mined in considerable quantity during the year. Limestone reserves although large and of a quality suitable for processed lime and portland cement were not exploited during 1947. Substantial quantities of lead, zinc, copper, chromium, and cadmium were mined during wartime but properties which produced these metals are now idle for the most part. Small quantities of platinum and silver were recovered during 1947 operations. Other minor resources of the county which were not exploited are brick clay, talc, mineral water, mineral paint, lignite coal, and manganese. A few diamonds of good quality have been taken from placers in Butte County over a long period of years.

Mining Activities During 1947. The most productive single operation in Butte County in the mineral industry during 1947 was the Lancha Plana No. 5 gold dredge on Butte Creek. This connected-bucket dredge had 65 electrically powered buckets of 4½ cubic-foot capacity. Such dredges are capable of digging 80 to 100 feet below the water line. Other large dredging operations were Yuba Consolidated Goldfields Butte Unit dredges; the Gold Hill Dredging Company's Kister dredge; Placer Exploration Company's Drescher Ranch dragline; Vasco Mining Company's Big Hill dredge; and Hoosier Gulch Placer's Boat No. 1 dragline. All of these worked in the Oroville district.

Several drift mines produced substantial quantities of gold-bearing gravels during 1947. The largest of these was the Morris Ravine or Split Rock mine in Morris Ravine, 3 miles northeast of Oroville. This operation was unique in that a ditch-digging machine was used to recover gravel from a tunnel large enough to admit the entire bulky apparatus. Other drift mines operated during 1947 were the Shawnee in the Butte Creek district and the Dally in the Magalia district.

The Surcease mine, a lode property 7 miles northwest of Yankee Hill, was operated by the Hoefling Brothers until April 1947, but since has closed down. Other lode mines reporting production for 1947 were the Wyoming in the Magalia district and the Monte at Understock.

The two largest producers of rock products in Butte County were the Henry J. Kaiser Rock Products Company on the main highway between Marysville and Oroville, and the Butte Creek Rock Company located on the Centerville road east of Chico. The latter has greatly increased its crushing plant in the last 2 years from a former capacity of 1,000 tons per day. Both the plants utilize the enormous piles of rock left by the gold dredges.

Several hundred tons of high-grade chrome ore were produced from the Lambert mine in Magalia district by Helmke, Thomas, and Janssen.

O.E.B.

Table 9. Mineral production from Butte County during 1947

Product	Quantity	Value
Chromite	308 short tons	[1]
Gold	27,037 troy ounces	$946,295
Sand and gravel	55,643 short tons	57,123
Silver	2,201 troy ounces	1,992
Unapportioned (chromite, natural gas, crude platinum metals, and stone)		306,000
Total value		$1,311,410

[1] Value included with "Unapportioned."

CALAVERAS COUNTY

Geologic Features. Calaveras County is situated principally in the Sierra Nevada, although the extreme northwestern portion lies close to the Great Valley. The county extends across the Sierra almost at right angles to the structural trend. Hence the structural and stratigraphic sequence in Calaveras County is a fair cross-section of the central Sierra Nevada as a whole. The geologic formations of the central Sierra have been conveniently divided into two major groups known as the subjacent or Bedrock series and the Superjacent or overlying series. The Superjacent series lies unconformably upon the Bedrock series and shows far less severe folding and metamorphism than does the Bedrock series.

The county can be divided into three areas on the basis of the bedrock lithology. The northeast quarter is made up mainly of granitic rocks of Upper Jurassic age with erosional remnants of Tertiary volcanics resting on them. The central half of the county consists principally of complexly folded and faulted metamorphic rocks of the Calaveras formation. Slate, schist, phyllite, quartzite, argillite, crystalline limestone, and greenstone members make up the Calaveras. Granitic rocks of great extent invade the formation in many places, and less extensive intrusions of ultrabasic rocks such as peridotite (serpentinized) and pyroxenite are common. The general structural trend of the folded bedrock is northwest but the central part of the county lacks the belted arrangement of the rocks of the western quarter. West of the Mother Lode, rocks of the Calaveras and Amador groups outcrop in alternating bands owing to tight isoclinal folding accompanied by faulting. The Mother Lode itself is a major structural feature of such magnitude that thousands of feet of strata are cut out by the faulting at various places along its 120-mile length. The system passes through Calaveras County in a northwesterly direction from Carson Hill on the Stanislaus River to Middle Bar on the Mokelumne River.

Another mineralized zone controlled largely by thrust faults more or less parallels the Mother Lode 8 or 10 miles to the west of it. Copperopolis, Campo Seco, and several other copper camps comprise the foothill copper belt of the Sierras, a mineral province almost as well known as the Mother Lode, though not nearly so productive. Substantial amounts of copper were produced along the belt during both world wars but copper mining is now at a low ebb.

In the Superjacent series of Calaveras County, the early Tertiary gravel channels at the base of the series have been of major economic

importance. They formed during the erosion of the upper parts of the gold lodes and consequently contain concentrations of placer gold. Later, rapid burial by mid-Tertiary pyroclastics and late Tertiary flow lavas preserved parts of the old river channels from the erosion that followed. However, unexposed parts must now be exploited by tunneling under the volcanic cap-rocks. The old river systems somewhat resembled the present stream systems in general distribution, but the mountain relief was far less than exists today. The climate was subtropical, and chemical weathering was very pronounced. This type of weathering was responsible for the large-scale decay of the gold lodes and for the formation of valuable deposits of quartz sand and clay.

Mineral Resources. Gold lodes and auriferous placers still form the principal mineral wealth of Calaveras County. Because of current labor conditions and high operation costs, however, only a few of the many deposits are now being exploited. Most of the recent mining activity has been in the West Point, Angels Camp, and Copperopolis districts. Copper reserves are in much the same status as gold. Large tonnages of low-grade sulfide copper ores still remain in the foothill copper belt.

Heavy production of zinc and lead from the Campo Seco district was reported through the war years but zinc production virtually ceased there in July 1947 when the Penn mine closed down. Substantial reserves of zinc-lead-copper ore still remain in the Campo Seco district.

Millions of tons of limestone suitable for portland cement and processed lime occur within the county boundaries. Calaveras County already has one of the largest portland cement plants of the state. Numerous deposits of limestone, which might be developed, are idle.

A high-iron clay suitable for ceramic shapes such as terra cotta pipe is mined in the vicinity of Valley Springs. Reserves in that part of the county are large. The clay is a high-strength type and is mixed with other clays to make ceramic batches that meet certain specifications. Clay shale is also mined in the Valley Springs district for similar purposes.

Several of the ancient channel-gravel deposits contain quartz crystals suitable for use in electronic devices. Several hundred pounds were mined for that purpose near Mokelumne Hill during the late war. Some crystals weighed more than 100 pounds. The deposits are by no means exhausted. Channel gravels are also an almost unlimited source of stone that can be processed into aggregate and road metal.

Small deposits of talc occur along the Mother Lode as hydrothermally altered parts of serpentine bodies. This material was once extensively mined and dressed for building facings. Another material widely used as building blocks, dressed stone, etc., is the indurated rhyolite tuff of the Valley Springs formation. This material is also suitable for crushing to aggregate or road metal.

Minor mineral resources of Calaveras County include mineral water, lead, and silver. Silver is produced largely as a by-product in the refining of gold, with which considerable silver is alloyed.

Mining Activities During 1947. The largest single operation in the county during 1947 was Calaveras Cement Company's portland cement plant at Kentucky House near San Andreas. Recent improvements and additions to the plant have increased its capacity to 7,500 barrels per day. New equipment includes two 87 Marcy mills and two 8 by 22 bob-tailed rake-classifiers in the raw-grinding department; three 48-inch

Telsmith cone crushers for secondary grinding; a new 10-ton crane for handling rock in raw storage; two 86 Marcy mills for finish grinding; and an increased truck fleet for hauling rock and cement.

The increased plant capacity required new assurances of sufficient long-time limestone reserves so an extensive diamond-drilling program was undertaken at No. 4 quarry. The program required 10 months to complete and more than 6,000 feet of holes were drilled. Sufficient high-grade limestone was developed to furnish raw material for full-capacity production for a long period of time. In addition, the drill cores outlined lenses of schists of different compositions which are particularly adaptable to the manufacture of the special cements now demanded by the market. The road to No. 4 quarry has been widened and improved to handle the increased traffic.

Activities planned but not yet completed include the installation of a Cottrell precipitator to control dust in stack gases, and enlargement of the capacity of the company reservoir to assure an adequate water supply during the driest seasons.

Calaveras Cement Company employs about 275 men at the plant.

The principal producing gold mines in Calaveras County were the Mountain King mine northwest of Copperopolis, the Centennial mine at West Point, the Penn mine at Campo Seco, and the Cuneo property on San Antonio Creek. Small intermittent production, both lode and placer, was reported from widely scattered points such as Linden, Camanche, Angels Camp, Altaville, Natoma, Waupt Creek, Railroad Flat, Glencoe, and Murphys.

At Campo Seco, the Shawmut Copper Mining Company operated the Penn mine until July and produced considerable gold and some silver as by-products in the recovery of zinc, lead, and copper. The ore was processed at the Eagle Shawmut mill, and gold- and silver-bearing pyrite concentrate was shipped. Lead was also a by-product of the ores in which the dominant metals are zinc and copper. Mining was carried on from the No. 2 and No. 3 shafts; most of the ore came from above the 1,400 foot level. The operators were H. C. Mueller and George W. Clemson of Chinese Camp; D. C. Peacock superintended the operation.

The Mountain King Mill and Mine Company of Fresno operated the Mountain King mine through 1947. This mine was one of the three largest producers in the county. The vein is at the contact of Mariposa slate and Logtown Ridge greenstone; it trends N. 32° W. and dips 25° to 30° NE. Considerable quantities of ore were found in hydrothermally altered greenstone adjoining the vein.

The Centennial mine at West Point (formerly the New Champion) was operated throughout most of the year under the management of M. G. O'Hanlon and Son. It is one of the few gold mines which has been operated continuously over a period of several years. Development is progressing through a 200-foot inclined shaft and drifts along the strike of the vein. The ore body strikes N. 8° to 10° W.; and dips about 60° W. and pitches south at a low angle. It has been exposed for a distance of 175 feet along the strike. The ore shoot is composed of pyrite, galena, and free gold in a quartz gangue. Both wall rocks are granodiorite. Average gold recovery has been in excess of $50.00 per ton, which is more than 90 percent. The mill and hoisting equipment have

been completely overhauled and considerable new equipment has been added.

The California Pottery Company continued to produce high-strength, high-iron clay at its quarries near Valley Springs. The clay is shipped to the company plant at Niles, California, where it is added to ceramic batches for sewerpipe and other fired clay products.

Brownlite Products continued to produce volcanic ash for use as lightweight aggregate from quarries near Valley Springs.

O.E.B.

Table 10. Mineral production from Calaveras County during 1947

Product	Quantity	Value
Copper	1,242,000 pounds	$260,820
Gold	5,171 troy ounces	180,985
Lead	90 short tons	25,920
Silver	97,076 troy ounces	87,854
Zinc	2,350 short tons	568,700
Unapportioned (cement, raw clay, pumice, sand and gravel, and stone)		3,075,042
Total value		$4,199,321

COLUSA COUNTY

General Geologic Features. The general topographic and geologic features of Colusa County present a striking belted arrangement along north-south lines. The eastern half of the county is in the flat-floored valley of the Sacramento River while the western half includes a series of parallel ridges of the Coast Ranges trending N. 10°-20° W. The succession of sharp narrow ridges and parallel narrow valleys has resulted in development of a perfect trellis drainage pattern with the major consequent streams running eastward to the Sacramento River and their subsequent tributaries carving north-south valleys at right angles to those of the major streams.

Structurally, the county is essentially the west limb of a syncline whose north-trending axis is not far from the Sacramento River. This structure has existed at least since early Pliocene time. A geologic section westward across the county would show then, first, the deep flat-lying Quaternary alluvium of the Sacramento Valley, a series of gently eastward-dipping discontinuous caps and terraces of Pleistocene gravels of the Red Bluff formation, then the underlying poorly sorted sandy siltstone beds of the upper Pliocene Tehama formation dipping 5° to 8° E., underlain in succession farther west by thick steeply dipping sandstones and shales of the Upper Cretaceous Chico formation, the Lower Cretaceous siltstones and shales (Horsetown), Upper Jurassic Knoxville and Franciscan formations, and finally along the western border of the county, a series of schists of possible Franciscan (?) and pre-Franciscan age. Two important structures interrupt the succession of eastward-dipping formations: The Rumsey anticline, extending southward from Williams in Colusa County over 30 miles to Capay in Yolo County, and the Sites anticline, 35 miles long, trending northward through the town of Sites in north-central Colusa County into central Glenn County. The Rumsey anticline is the principal structure of the low Rumsey Hills and

involves steeply folded Upper Cretaceous beds, faulted along the west limb, and surrounded by Eocene and upper Pliocene sedimentary strata; only the northern end of the anticline extends into Colusa County. The Sites anticline is an extremely narrow elongated isoclinal fold with vertically dipping Lower Cretaceous Horsetown beds exposed at the crest. The Horsetown beds, probably 5,000 feet thick, are flanked by 9,700 feet of Upper Cretaceous Chico sandstones and shales which lie unconformably on the Horsetown greenish siltstone and shale. The anticline is complicated by northeast-striking oblique faults with chiefly horizontal displacement. The syncline to the west is a broad gentle fold.

Tertiary formations of Colusa County were discussed by Anderson and Russell [14] with an accompanying reconnaissance geologic map of the area. Geologic reports and maps by Kirby [15] cover the Rumsey and Sites anticlines.

Mineral Resources. A small amount of chromite was mined from lenses in serpentine in 1918. Gold has been mined from shallow deposits in sandstone and shale near the contact of Franciscan shales with intrusive serpentine near Wilbur Springs. Hot saline and sulphur springs and cool carbonate springs occur in the western part of the county near the contact of Cretaceous sediments with Franciscan metamorphic rocks, and the ultrabasic rocks that intrude the latter.

Seepages of oil occur in the Wilbur Springs district in the Knoxville shales near the contact with Franciscan chert and serpentine; in Knoxville sandstone beds along the axis of an anticline near Mountain House; and along the bottom of Sand Creek where it cuts through a small fold in the Chico beds west of Arbuckle. Gas seepages on the Rumsey Hills anticline in southern Colusa County and along the crest of the Sites anticline in the north central part of the county led to the drilling of a number of wells, beginning in 1900 in the Rumsey area and 1925 in the Sites area. All were abandoned as non-commerical, although showings of gas and salt water were usually encountered.

Cinnabar occurs in seams in serpentine and in the altered shales, sandstones, and conglomerates near serpentine contacts. It is associated with seams and ledges of silica carbonate rocks.

Massive sandstone, of Upper Cretaceous age, was quarried for many years from an area just east of Sites in upper Stone Corral Creek in the north central part of the county. The rock is a compact blue-gray sandstone, weathering buff to gray, in beds from 18 inches to 18 feet thick, which crop out for 20 miles from the northern to the southern part of the county, striking approximately N. 20° W. and dipping about 40° E. under the younger Tehama gravels and alluvium of the Sacramento Valley. The quarry was most active from its opening in 1891 to 1913. It is of especial interest as it supplied "Colusa sandstone" [16] for many well-known buildings in San Francisco, Sacramento, San Jose, Monterey, and Hawaii. Among such are the Ferry building, Flood building, Merchants National Bank, and St. Francis Hotel in San Francisco. The excellence of the stone as a building material is illustrated by the fact that the Ferry

[14] Anderson, Charles A., and Russell, R. Dana, Tertiary formations of northern Sacramento Valley, California: California Jour. Mines and Geology, vol. 35, pp. 219-253, 1939.

[15] Kirby, J. M., Rumsey Hills area: California Div. Mines, Bull. 118, pp. 601-605, 1943, and Kirby, J. M., Sites region: California Div. Mines, Bull. 118, pp. 606-608, 1943.

[16] Colusa County: California Min. Bur. Bull. 38, pp. 118-125, 1906, and Rept. XIV, pp. 191-195, 1915.

building, built in 1896 and first to use Colusa stone, shows only minor spalling and other weathering effects in 1948. Sand and gravel deposits are mined on the banks and bars of the Sacramento River and tributary creeks. Salt has been produced by evaporating water from saline springs in Antelope Valley near Sites. Sulphur occurs in the quicksilver deposits at Sulphur Creek.

The mines and mineral resources of Colusa County have been described by Logan.[17]

Significant Activities During 1947. The mineral production of Colusa County for 1947 consisted of gold, silver, sand and gravel. The latter was mined from four pits on the west bank of the Sacramento River between Colusa and Princeton. The material was used on roads and as an aggregate for concrete.

J.C.O.

Table 11. Mineral production from Colusa County during 1947

Product	Quantity	Value
Gold	6 troy ounces	$210
Sand and gravel	225,729 short tons	89,750
Silver	3 troy ounces	3
Total value		$89,963

CONTRA COSTA COUNTY

General Geologic Features. Contra Costa County embraces 734 square miles of land area on the southern shores of San Pablo Bay, Carquinez Straits, Suisun Bay, and the San Joaquin River. The most prominent topographic and structural feature is Mount Diablo situated approximately in the geographical center of the county. It is one of the highest peaks in the central Coast Ranges, rising to an elevation of 3849 feet, and has been selected as the initial point in the survey of the General Land Office controlling most of central and northern California.

Mount Diablo, according to Taff,[18] is an oval-shaped mass of igneous, sedimentary and metamorphic rocks of the Franciscan (Jurassic) formation covering about 15 square miles, protruding through the center of an anticlinal fold 50 miles long. The trend of the fold is northwestward and its flanks are composed of Cretaceous and Tertiary rocks which make parallel ridges of erosion about 2,000 feet high on the northeast and southwest sides of the mountain. Both Lower and Upper Cretaceous rocks are exposed and the Tertiary section consists of lower Eocene to Pliocene rocks. Quaternary alluvium covers the Tertiary and Cretaceous rocks in Ygnacio Valley northwest of Mount Diablo and in the eastern part of the county along the delta of the San Joaquin River.

The geologic structure of the Mount Diablo area consists of two elements: first, the anticlinal fold, developed at the close of the Tertiary period, which traverses the county in a northwestward direction and extends beyond its borders in both directions; and second, the upthrust

[17] Logan, Clarence A., Colusa County: California Div. Mines Rept. 25, pp. 284-300, 1929.

[18] Taff, J. A., Geology of Mt. Diablo and vicinity: Geol. Soc. America Bull., vol. 46, pp. 1079-1100, 1935.

of the core of Franciscan rocks, as a fault plug, through the overlying Upper Jurassic and Cretaceous strata in the center of the anticline. The upthrust occurred after the close of the Tertiary period. The foothills on the southwest flank of the mountain are covered by continental sediments and interbedded volcanics of Pliocene age which form a syncline, overturned to the southwest. These foothills descend on the west into the narrow trough of the northwest-trending San Ramon Valley. Drainage here is northwestward and the west side of the valley is the locus of the Sunol-Southampton (Calaveras) thrust fault. North of the town of Walnut Creek the Southampton fault cuts into the northwest limb of the Mount Diablo anticline.

A series of northwest-trending ridges marks the uplifted block west of the Southampton fault. The strata exposed range in age from Pliocene to Jurassic. Structurally they represent a series of anticlines and synclines locally faulted and overturned at numerous points. Eventually they merge westward with the tidal marsh of the bay.

Mineral Resources. The mineral resources of Contra Costa County are particularly important because they are close to the industrial centers surrounding San Francisco Bay. The important commercial minerals are: clay and shale for brick-making, limestone, mineral water, natural gas, pumice, quicksilver, sand, silica (molding and glass sand), and miscellaneous stone (crushed rock). Clay and shales at Richmond and Port Costa provide raw material for making common red brick. The production of sub-bituminous coal began in 1861 from Eocene beds on the northeast flanks of Mount Diablo. About 3,000,000 tons, valued at $15,000,000 had been produced by 1902 when mining ceased entirely. Conspicuous outcrops of Recent limestone (travertine), used in cement making , are found along Lime Ridge about 5 miles southeast of Concord. The cement plant is located at Cowell. Mineral water from this county has been produced commercially for many years. The county also supplies molding (silica) sand for the local steel industry centered around Pittsburg. The southeast end of the Rio Vista gas field extends into Contra Costa County and seven wells operated by the Standard Oil Company produce gas from Eocene sands at a depth of about 4,500 feet. Pumice in the form of a pumiceous tuff is found in the Pliocene volcanics extending northwestward from Mount Diablo. Quicksilver, chiefly as metacinnabarite, is produced from ore bodies along the Franciscan serpentine-sandstone contact on the east side of Mount Diablo. Deposits of fine dune sand of Quaternary age on the south shore of the San Joaquin River are mined in the vicinity of Antioch. Miscellaneous stone (crushed rock) is obtained from metamorphosed Franciscan sandstone and chert at numerous points throughout Contral Costa County. Small amounts of asphalt, copper, diatomite, gold, lead, and silver, have been produced.[19]

Significant Activities During 1947. Brick-making and the manufacture of clay products, dinner-ware, and sanitary-ware, are important elements of the mineral industry in Contra Costa County. Local clay and shale are used by two brick companies in the manufacture of common red brick and hollow building blocks. Three additional plants purchase high-grade clays from Placer and Amador Counties which they use in making fire-brick, sanitary-ware, and clay products. A dinner-ware plant

[19] Laizure, C. McK, San Francisco field division—Contra Costa County: California Div. Mines Rept. 23, pp. 2-31, 1927.

purchases Tesla clay which it blends with crude clay from out-of-state deposits.

Natural gas is produced from the southern end of the Rio Vista gas field which extends into Contra Costa County. The seven producing wells are controlled by the Standard Oil Company and gas is delivered to the Pacific Gas and Electric Company pipe line. It is possible that additional wells may be drilled in this area.

Mineral water is produced commercially from springs located near Martinez at Alhambra Springs and Oak Springs. This water is bottled and distributed for consumption in the San Francisco Bay area.

A small quantity of pumice is produced from a pumiceous tuff occurring in the foothills east of Pittsburg. The crude material is crushed, screened, and used as an aggregate in the manufacture of building blocks.

Clay-free foundry sand is produced in small quantities from dipping beds of Eocene sandstone south of Antioch. The crude sand is washed, classified, and is used in preparing synthetic sands for iron foundries. A similar sand is also produced from Eocene beds in the workings of the old Nortonville coal mine near Clayton.[20] The sand is mined by drifts and overhand stopes. It is transported to a crushing and washing plant near Pittsburg where it is prepared for use in steel and iron foundries. The silica content of the end products from these two operations is 95 percent.

The south shore of the San Joaquin River in the vicinity of Antioch is bordered with dunes of fine sand. A number of operators, using dragline-buckets, load this sand directly to railroad cars for shipment to asphalt plants.

Large quantities of crushed rock are produced from indurated sandstone at Blake Bros. Richmond quarry. Basalt is the source of crushed rock at the Upton quarry of Henry J. Kaiser Company.

F.F.D.

Table 12. Mineral production from Contra Costa County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[1]
Sand and gravel	378,734 short tons	$248,403
Stone	472,020 short tons	509,546
Unapportioned (raw clay, natural gas, and pumice)		630,733
Total value		$1,388,682

[1] U. S. Bureau of the Census not at liberty to publish figure. Value not included in county total.

DEL NORTE COUNTY

General Geologic Features. Del Norte County lies within the rugged and complex Klamath Mountains province. Intrusive rocks, chiefly serpentine and peridotite, cover most of its area except for a belt of Franciscan sandstone and shales 5 to 10 miles wide along the coast, and the outcrops of diorite and granodiorite that make up the mountains along the border of Siskiyou County. Small areas of diorite and granodiorite also occur in the serpentine belts, and there are remnants of meta-

[20] Wright, L. A., California foundry sands: California Jour. Mines and Geology, vol. 44, pp. 37-72, 1948.

morphic, sedimentary, and volcanic rocks which have been intruded by both the granitic rocks and the peridotite. The geology of Del Norte County is shown on maps prepared by Maxson [21] and published by the California State Division of Mines.

Mineral Resources. Chromite occurs in lenses in serpentine. Copper minerals, chiefly chalcopyrite, are also found in veins and lenses in serpentine at or near the contact with granitic rocks. Pyrite and pyrrhotite are accessory minerals. Gold and platinum are found in the stream gravels and beach sands associated with magnetite and chromite. Gold also occurs in narrow quartz veins and stringers in greenstone and slate near the contact with diorite and granodiorite. Native quicksilver and cinnabar occur in vugs and fissures in serpentine and the rocks in contact with it. Sand and gravel are mined from the banks and bars of the Smith River, and heavy boulders for building the harbor jetties were quarried from the greenstone outcrops on Preston Island. The mines and mineral resources of Del Norte County have been described by Laizure [22] and Maxson.[23]

Significant Activities During 1947. The Tyson chrome mine at French Hill was converted into an open-pit operation in 1947. Water was brought from French Hill through 2¼ miles of ditches and delivered to a No. 3 giant under a 250-foot head. The physical characteristics of this deposit are favorable for a hydraulic operation. The serpentine is soft and broken and a good slope provides plenty of dump room for tailing. Chromite occurs in irregular lenses and was difficult and expensive to mine by underground methods.

Shults Brothers installed a 25-ton Lacy rotary furnace at the Webb quicksilver mine during the year, and a new adit was driven to develop the deposit at a lower elevation. A bunk house and dining hall were built to accommodate the crew.

Rock was quarried at Preston Island and used to build the jetties at Crescent City harbor. Sand and gravel were mined from pits on the banks of Smith River and used for concrete aggregate and on roads.

J.C.O.

Table 13. Mineral production from Del Norte County during 1947

Product	Quantity	Value
Chromite	640 short tons	[1]
Sand and gravel	55,017 short tons	[1]
Unapportioned (chromite, sand and gravel, and stone)		$322,156
Total value		$322,156

[1] Value included with "Unapportioned."

EL DORADO COUNTY

General Geologic Features. Northernmost of the Mother Lode counties, El Dorado County is bordered on the west by Sacramento and Placer Counties. It extends from the lower foothills on the west, up the

[21] Maxson, J. H., Economic geology of portions of Del Norte and Siskiyou Counties, northwesternmost California: California Div. Mines Rept. 29, pl. 4, 1933.

[22] Laizure, C. McK., Del Norte County: California Min. Bur. Rept. 21, pp. 281-294, 1925.

[23] Maxson, J. H., Economic geology of portions of Del Norte and Siskiyou Counties, northwesternmost California: California Div. Mines Rept. 29, pp. 123-160, 1933.

gradually rising slope of the Sierra Nevada to the summit of the range (8,000 to 10,000 feet) thence across Lake Valley to the Nevada state line. Part of Lake Tahoe is included within its limits. It occupies part of the drainage basin of the Middle Fork of American River and the larger part of the area drained by Cosumnes River. The western region was, in Cretaceous time, part of an extensive peneplain occupied by Jurassic and Paleozoic formations; there are no marine deposits younger than the Mariposa (Upper Jurassic) clay slate.

In El Dorado County, the western part of the bedrock complex consists largely of altered igneous rocks derived from basic tuff and other basic volcanic debris. Through dynamic metamorphism, the fragmentary material has been changed principally to chlorite or amphibolite schist. The principal Jurassic metasediments of economic importance are the Mariposa slate beds of the Mother Lode belt which cross the county from north to south by way of Georgetown, Placerville, and Nashville. In the southern part of the county this slate strikes north and is bordered on the west by the Logtown agglomerate, which has been placed as upper Middle to lower Upper Jurassic by Taliaferro.[24] Near Diamond Springs the slate strikes northeast, but north of Placerville it again strikes north-northwest. From Garden Valley northward, the slate is divided into two strands by a large wedge of amphibolite schist. The Mother Lode veins occur in both the slate and schist, as well as along the borders of narrow serpentinized dikes occasionally found in the slate. An important ancient river system, possibly in part as old as the Cretaceous, but mantled by middle Tertiary rhyolite and andesite, crossed the Mother Lode just south of Placerville. It was partly exposed by later erosion and yielded great quantities of gold to the pioneers.

West of the Mother Lode the meta-igneous rocks as well as the Paleozoic metasediments were extensively invaded by gabbrodiorite and granodiorite and by smaller bodies of ultrabasic rocks. The last named have since been serpentinized.

Following profound erosion during the Cretaceous, the birth of the present Sierra Nevada began, accompanied by the rejuvenation of streams in the early Tertiary. Finally, outbursts of rhyolite ash followed by repeated and much more extensive eruptions of andesite came from the mountains to the east. The quantity of the andesite, which descended the slope in the form of mud and breccia, was sufficient to fill entire valleys. Large river canyons and their deposits were thus covered and protected until found by the pioneer gold miners. Modern stream systems established since the end of that volcanic era have stripped off a great deal of the volcanic cover and much of the older metasediments, and have exposed the underlying granitic rocks both east and west of the Mother Lode. Long sections of ancient stream channels were washed out and the gold they contained was again concentrated, this time in the modern streams.

East of the Mother Lode and west of the summit of the Sierra Nevada, the remaining older rocks that only partially cover the granite are Paleozoic (Calaveras formation). The rocks of this Paleozoic complex include clay slate and phyllite, altered limestone and sandstone, quartz-mica schist and graphitic schist, chert, and a variety of altered

[24] Taliaferro, N. L., Manganese deposits of the Sierra Nevada—their genesis and metamorphism: California Div. Mines Bull. 125, p. 284, 1943.

volcanic rocks, now largely changed to schist. This is the East Belt of the gold miner.

Due to pressure from the invading granodiorite, all of the older rocks, including the Mariposa and other Jurassic beds on the west, have been closely folded and rendered schistose; the schistosity strikes northwest and dips steeply northeast. Long ridges with gentle westward slopes covered with andesite tuff and breccia extend into the higher mountains east of the Calaveras rocks. In these mountains also are many remnants of Pliocene moraines. Some roof pendants of clay slate and associated augite porphyrite on the eastern slope near Lake Tahoe have been called Juratrias.

Two important faults have been mapped. One is the Mother Lode reverse fault system and the other is the great fault system along the eastern side of the Sierra Nevada, running nearly north through Lake Valley and Lake Tahoe.

Mineral Resources. Until 1917, gold was the most important mineral product of the county. In the period of rising wages and costs prior to 1930, gold production was small, but a sharp revival came with the depression of 1932, and from 1933 to 1943 the county yielded $15,000,000 in gold. The period of extremely high wages and prices since the end of the last war has been unfavorable for gold mining and recovery is only gradual. Prior to 1943, both lode mines and dragline dredges were productive. The dredging land has been quite thoroughly exploited; the acreage of this land was small. The remaining lode mining possibilities are numerous. Gold-bearing veins occur not only in the Jurassic clay slate and schists of the Mother Lode, but also in most of the rocks of the bedrock complex and around the borders of the invading granitic rocks, on both sides of that lode and as far east as Grizzly Flat at an elevation of about 4,000 feet. In this gold-bearing region, approximately 30 miles square, is a great variety of gold deposits ranging from base ore and low-grade auriferous sulfides through the free-milling, medium-grade, slate-quartz ores of the Mother Lode to the specimen gold of the seam diggings and the more complex but often good grade ores of the Paleozoic East Belt rocks.

Large deposits of high-calcium limestone, mostly altered to dense, fine-grained marble, occur near Cool, in Marble Valley, near Rattlesnake Bar, and north of Dugans. These Paleozoic deposits have been closely compressed and tilted so that they appear as lenses standing on edge. Two such lenses have been worked to a vertical depth of 800 feet. Magnesian limestone is also quarried east of Diamond Springs for making lime.

More than 40 years ago, chrysotile asbestos was produced from serpentine areas near Georgetown and Greenwood. The county was one of the larger producers of chromite in 1915-18 and some production was made during the last war. Considerable disseminated ore remains which requires further experimental work in concentration before an economic product can be recovered. Copper has been mined in small amounts when price permitted, and one producer has been active recently. Some of mines and prospects are in amphibolite schist, but many are of contact-metamorphic type, at the borders of granitic rocks. These copper ores carry some gold and silver. Iron ore and scheelite have been mined in only small quantities. Lead and silver are by-products of gold-quartz ores, and small amounts of the platinum-group metals have been recovered

with placer gold. Some pyrite was shipped 30 years ago. Silica from veins in White Rock Canyon has been shipped for use in cleaning compounds.

The black slate of the Mother Lode belt between Placerville and Kelsey is excellent for roofing granules and for sawing into slate shapes. From 1895 to 1912 substantial quantities of slate shingles were produced from several quarries there. At present the only use made of this slate is for roofing granules. Numerous soapstone quarries have been worked. Those most recently exploited are located near the railroad in the vicinity of Brandon and Latrobe. Deposits are also known near Shingle Springs, Placerville, and east of Diamond Springs. Sand and gravel are available for local use. White rhyolite ash deposits at Smiths Flat are so far undeveloped.

Significant Activities During 1947. El Dorado County is one of the leading producers of high-calcium industrial limestone in the state. Two modern lime plants are located within its boundaries. At present, the value of these products exceeds half a million dollars annually, and the only close competitor in either tonnage or value of output for this purpose is San Bernardino County. Several counties produce larger tonnages of limestone than El Dorado, but the bulk of it is mined for use in portland cement.

California Rock and Gravel Company operated a large quarry near Cool where a nearly pure high-calcium limestone was produced for beet-sugar refining and other industrial uses. This company also supplied limestone during 1947 to the new plant of Auburn Lime Products Company, 10 miles distant. The latter operated a rotary kiln for making several sizes of lime and also had equipment for crushing and screening limestone for poultry grits, glass, etc. This company's own limestone deposit, which produced stone for lime and other uses off and on since the sixties, is not being worked at present.

At Diamond Springs, the large modern lime plant of Diamond Springs Lime Company utilizes magnesian limestone from its own quarry about 5 miles east of the plant to make lime for plaster, and also burns lime from the underground mine of El Dorado Limestone Company. The latter company has been producing a very fine quality of white high-calcium limestone from workings that have reached a vertical depth of about 800 feet. They have a washing and hand-sorting plant to raise the grade of the limestone, which goes to steel mills (after being burnt to lime). This limestone is also sold for use in paint, sugar-refining, glass, etc. The limestone deposits of California, including those in El Dorado County have been described in detail in a recent report by Logan. The limestone industry in El Dorado County employs 150 or more men.

Pacific Minerals Company, Limited, operates a crushing and screening plant at Chili Bar on the South Fork of American River where the black Mariposa clay slate of the Mother Lode belt is made into roofing granules for use on "ready roofing" and shingles. The by-product dust and some crude slate are also marketed.

Gold production in 1947 amounted to $104,790 which came from 13 small lode mines and 12 placers. More than $91,000 of this was from placers, principally small dredging operations. Shortage of water in the western part of the county hampered lode mining by the middle of summer, and caused some shutdowns. The Lilyama mine which has

copper- and gold-bearing ore, and the Shaw (Volo) mine were worked part of the year. The Grit mine at Spanish Dry Diggings was equipped with a mill and was prospected by Liddicoat Gold Mines Company.

Soapstone is quarried by Pacific Minerals Company, Limited, from a deposit alongside the railroad at Shrub Spur, north of Brandon.

C.A.L.

Table 14. Mineral production from El Dorado County during 1947

Product	Quantity	Value
Copper	112,000 pounds	$23,520
Gold	2,994 troy ounces	104,790
Lead	2 short tons	576
Silver	2,039 troy ounces	1,845
Stone	211,780 short tons	483,991
Zinc	6 short tons	1,452
Unapportioned (lime, sand and gravel, slate, and soapstone)		1,024,846
Total value		$1,641,020

FRESNO COUNTY

General Geologic Features. Fresno County extends from the Coast Ranges across the San Joaquin Valley to the crest of the Sierra Nevada. A rather complete series of Tertiary and Cretaceous sediments resting on the Franciscan is exposed in the southwestern part of the county. The same series is known to underlie the recent alluvium of the San Joaquin Valley because of extensive drilling for petroleum at such places as Coalinga and Kettleman Hills. To the east of the alluvium occupying the valley, which is about 50 miles wide, are exposures of the granitic core of the Sierra Nevada and older metamorphosed sediments.

Mineral Resources. The outstanding mineral products of Fresno County are petroleum and natural gas, which are found at several Tertiary horizons, including the Eocene, at Coalinga and Kettleman Hills. Gravel, sand, and crushed rock are produced on a large scale by dragging the stream gravel, and crushing and screening the oversize. Brick and hollow tile are produced from local clay at Fresno. Chromite is associated with ultrabasic intrusive rocks in both the Sierra Nevada and the Coast Ranges. Manganese, as rhodonite or rhodochrosite, is associated with chert in these same localities. Most of the manganese occurrences are in the Sierra Nevada, but the only production has come from one deposit in the Franciscan of the Coast Ranges at the southwestern edge of the county. At the western side of the county is a quicksilver district associated with Cretaceous sandstone. Tertiary volcanics which occur nearby suggest a possible origin for this mineralization. Tungsten is found in the Sierra Nevada associated with contacts of the granite with the metasediments. Brown garnets containing lime often accompany the scheelite. Granite is quarried from the extensive deposits of the Sierra for cutting into monuments. Minor amounts of placer gold are produced from the deposits mined primarily for gravel, sand, and crushed rock; also from deposits of fine gravel and sand by means of suction dredges. Deposits of diatomite and gypsum are known to occur in the county, but they have not been extensively developed. Deposits of limestone occur in the

metasediments near Dunlap and Tollhouse about 40 miles by road east of Fresno.

Significant Activities During 1947. Production of petroleum and new drilling continued at fields near Coalinga, and a number of new producing wells were completed in this area. A new discovery of petroleum in the Eocene was made at a point 3 miles southeast of the town of San Joaquin. Production of marl containing a high percentage of lime has been started recently from a deposit about 25 miles west of Fresno. Production of sand, gravel, and crushed rock continues at a high level.

C.V.A.

Table 15. Mineral production from Fresno County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[1]
Gold	235 troy ounces	$8,225
Natural gas	63,814,000 M. cu. ft.	6,750,000
Natural gasoline and allied products:		
Natural gasoline	75,836,000 gallons	3,948,000
Liquefied petroleum gases	41,690,000 gallons	1,699,000
Petroleum	44,133,000 barrels	75,388,000
Sand and gravel	1,031,322 short tons	1,141,346
Silver	37 troy ounces	33
Stone	164,910 short tons	292,835
Unapportioned (raw clay, crude feldspar, crude gypsum, mercury, pumice, and tungsten concentrates)		114,872
Total value		$89,342,311

[1] U. S. Bureau of the Census not at liberty to publish figure. Value not included in county total.

GLENN COUNTY

General Geologic Features. The eastern third of Glenn County is within the Sacramento Valley and is covered with Quaternary silt, sand, and gravel. The western portion is within the foothills of the northern Coast Ranges and includes north- and south-trending belts of Jurassic and Cretaceous conglomerate, sandstone, and shale. In the north central portion of the county, patches of Cretaceous shale and Pliocene basalt outcrop in an area of Pliocene nonmarine sediments 3 to 10 miles wide, that extends about 18 miles south from the border.

The general geologic features of Glenn County, lying directly north of Colusa County and in a similar position, are very much like those of Colusa County, previously described. The Anderson and Russell [25] report also covers a portion of Glenn County.

Mineral Resources. Chromite occurs banded and disseminated in the narrow belt of serpentine that trends northwestward along the eastern slope of the northern Coast Ranges. Copper prospects occur in several places in western Glenn County. Float containing native copper was found in an adit driven in serpentine about 2 miles north of Chrome. Narrow stringers bearing gold, silver, and copper occur in the Franciscan formation northwest of Elk Creek. Manganese oxides and silicates occur in chert beds in the Franciscan formation in ten localities in Glenn County. Natural gas occurs in Cretaceous beds at a depth of 2,240, feet about 7 miles northeast of Willows. There are extensive deposits

[25] Op. cit.

of sand and gravel in many areas in the Sacramento Valley. The mines and mineral resources of Glenn County have been described by Averill.[26]

Significant Activities During 1947. Mineral production for 1947 consisted of sand and gravel mined from creek beds. Madsen and Cramer operated a pit on the North Fork of Willow Creek, and the Orland Sand and Gravel Company operated a pit on Stony Creek north of Orland. The material was used for roads, stock corrals, and for concrete aggregate.

A small quantity of natural gas was also produced.

J.C.O.

HUMBOLDT COUNTY

General Geologic Features. The northern Coast Ranges trend in a northwesterly direction through Humboldt County, and contact a belt of pre-Cambrian metamorphic rocks of the Klamath Mountain province on a line extending southeastward through the county from a point about 5 miles south of Orick to the middle of the eastern border. Franciscan sediments, mostly shale, argillaceous sandstone, and chert, cover the largest area included in the northern Coast Ranges within the county. They have been strongly folded and faulted and the strata dip at steep angles.

A belt of Quaternary and Pliocene sediments 6 to 15 miles wide outcrops along the coast line for some 16 miles north and 20 miles south of Eureka, and extends inland along the Eel and Mad River valleys for some 30 miles. A considerable thickness of dark organic shales of Cretaceous age is in contact with the Franciscan formation in the areas west of Briceland and Bridgeville. The northeastern portion of the county, within the Klamath Mountain province, includes a wide belt of pre-Cambrian metamorphic rocks trending northwestward and flanked by Franciscan and Pliocene sediments near the coast. Belts of Jurassic granitic rocks, metamorphic rocks, and serpentine, are cut by the Klamath River as it flows southwestward through the northeast corner of the county. The geology of Humboldt County is shown on maps prepared by Smith.[27]

Mineral Resources. Chromite occurs in lenses in serpentine that outcrops in the northeastern portion of the county. Clay suitable for the manufacture of brick and hollow tile occurs in the Quaternary sediments along the coastal plain. Lignite has been found in sandstone and clay beds in Eureka and in several localities along the Eel River and its tributaries. Native copper, bornite, chalcocite, and chalcopyrite are found in serpentine cut by gabbro dikes on Horse Mountain. Chalcopyrite and sphalerite, associated with pyrite and carrying gold and silver, occur in veins between shale and schist on the Hoopa Reservation. Placer gold with silver and platinum is found in the beach sands, stream, and terrace gravels of the Klamath and Trinity Rivers. Limestone deposits occur in the Franciscan and Pliocene formations in several localities. Manganese minerals, oxides, carbonates, and silicates, are found in beds and lenses associated with chert in the Franciscan formation. Natural gas and oil showings occur in the sedimentary rocks in the southwestern part of the county. Commercial natural-gas wells have

[26] Averill, Charles V., Glenn County: California Div. Mines Rept. 25, pp. 418-426, 1929.

[27] Op.cit.

been developed in the Pliocene sands at 3,800 to 5,000 foot depths about 2½ miles east of Fernbridge. Sand, gravel, and crushed rock are produced from the banks and bars of the Eel and Mad Rivers. The mines and mineral deposits of Humboldt County have been described by Averill.[28]

Significant Activities During 1947. Hydraulic mines operated on bench gravels and old river channels along the Klamath River above Orleans. The Copper Bluff Mining Company was formed and resumed the development of the pyritic zinc-copper deposit on the Hoopa Indian Reservation. Sand and gravel were mined from pits on the banks of the Mad River and used for roads and concrete aggregate. Brick and pottery clay and natural gas also contributed to the mineral production of Humboldt County during 1947. J. C. O.

Table 16. Mineral production from Humboldt County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[2]
Gold	139 troy ounces	$4,865
Sand and gravel	261,063 short tons	221,278
Silver	22 troy ounces	20
Stone	60,120 short tons	[1]
Unapportioned (raw clay, natural gas, and stone)		90,201
Total value		$316,364

[1] Value included with "Unapportioned."
[2] U. S. Bureau of the Census not at liberty to publish figure. Value not included in county total.

IMPERIAL COUNTY

General Geologic Features. Imperial County, with an area of 4,089 square miles, is dominated by the Salton Sea basin and is mostly within the Colorado Desert geomorphic province. The Chocolate, Palo Verde, and Cargo Muchacho Mountains, lying between the Salton basin and the Colorado River, are a part of the Mojave Desert province. The Laguna and Vallecito Mountains of the Peninsular Ranges province extend into the southwestern corner of the county.

The Salton basin, a continuation of the trough of the Gulf of California, is separated from that by a very large delta of the Colorado River. This trough is a sunken fault block between active branches of the San Andreas fault. Ancient beaches and water lines show that this basin was once occupied by an extinct lake (Cahuilla). During the years 1905-07 it was again filled, by flooding of the Colorado River, to form the present Salton Sea. Sedimentation probably began in this basin in late Tertiary time [29] and was partially marine and partially terrestrial, as indicated by fossils and by gypsum and strontianite deposits around Fish and Carrizo Mountains. Quaternary sedimentation was mostly terrestrial, but some took place in Lake Cahuilla.

The wind-deposited sand hills east of Imperial Valley constitute one of the largest belts of dunes in the United States and form a range of low hills 40 miles long and 2 to 6 miles wide. The Palo Verde Mountains in the northeast corner of the county are made up mainly of Ter-

[28] Averill, Charles V., Humboldt County: California Div. Mines Rept. 37, pp. 499-528, 1941.
[29] Brown, J. S., The Salton Sea region, California: U. S. Geol. Survey Water-Supply Paper 497, 1923.

tiary volcanics. The Chocolate Mountains, forming the northeastern wall of the Salton basin, are composed partly of pre-Cambrian and pre-Cretaceous metamorphics intruded by Jurassic granitics, and partly of Tertiary andesitic and rhyolitic lava flows. The geology of the Cargo Muchacho Mountains to the south was described by Henshaw.[30] In this range, pre-Mesozoic metamorphics have been intruded by a series of granitoid rocks, probably Mesozoic in age. There is also evidence that the Colorado River formerly flowed through the region. The Peninsular Ranges have a Jurassic acid-intrusive core which intruded existing sediments, some of which were Paleozoic, possibly Carboniferous. The Picacho Mountains on the southeast corner along the Colorado River basin are mainly volcanics underlain by pre-Mesozoic metamorphics.

Mineral Resources. Imperial County has produced copper, gold, lead, manganese, and silver in addition to 21 different nonmetallic substances. Of these the most important have been miscellaneous stone products, salt, gypsum, kyanite, strontium, brick, mica schist, and carbon-dioxide gas.[31]

Production of copper has been from the concentrates produced at the American Girl mine in the Cargo Muchacho district. Mined for gold, the ore was concentrated, and this concentrate carried 3 to 5 percent copper. Oxidized copper mineralization occurs in the Picacho and Paymaster districts and on the west slope of Fish Mountain. Some sulphides have been noted in the monzonite of the Paymaster district of the Chocolate Mountains. Manganese has been produced mainly from the Paymaster district, but also occurs in the Palo Verde Mountains. Gold has been mined to some extent in every range, but the most productive area has been in the Cargo Muchacho and Picacho Mountains. Nearly 2½ million dollars in gold production has been reported since 1907, the latest in 1942. Lead-silver ores occur in the Picacho Mountains and the Paymaster district. In the Paymaster district the Paymaster mine has been the most productive.

Prior to the formation of the present Salton Sea, salt was obtained from the saline crust on the old sea bed. Since the filling, it has been obtained by evaporation of the sea waters. Strontium ore (celestite) has been mined from a low hill on the north side of Fish Mountain. The celestite beds overlie gypsum beds in a sedimentary section and both are considered to be marine deposits, probably Tertiary in age. Kyanite has been mined from the Cargo Muchacho district, which has also produced mica in the form of sericite schist. Both occur in the Vitrefrax formation[32] which consists of metamorphics probably derived from sediments. The kyanite was difficult to separate from the quartz, and this problem has inhibited its use in recent years. Carbon-dioxide gas has been produced from the gas field southeast of the Salton Sea near Niland, first production having been in 1933. The most important nonmetallic mineral in Imperial County is gypsum, production going mainly into industrial uses. The deposit being mined is that of the United States Gypsum Company north of Plaster City on Fish Mountain. Other large deposits occur on Carrizo and Coyote Mountains.

[30] Henshaw, P. C., Geology and mineral deposits of the Cargo Muchacho Mountains, Imperial County, California: California Div. Mines Rept. 38, pp. 147-196, 1942.

[31] Sampson, R. J., and Tucker, W. B., Mineral resources of Imperial County: California Div. Mines Rept. 38, pp. 105-145, 1942.

[32] Henshaw, P. C., op. cit.

Significant Activities During 1947. Cardox Western, Inc. continued their operations in the Salton Sea carbon-dioxide gas field. Experimental work was carried on in the attempt to prolong the productive life of the wells, which, due to technical difficulties, averages only about 2 years. Several wells were drilled as part of a rather constant drilling program. The average well depth is about 635 feet. Most of the carbon-dioxide is marketed as dry ice and a small amount as liquid CO_2. There are at least 50 different uses for carbon-dioxide in its marketed forms.[33]

Operation of the kyanite quarry near Ogilby by the Vitrefrax Corporation was discontinued in 1946, but a small amount of kyanite was produced by the Western Non-Metallics Company of Ogilby in their mica-schist operation. The productive capacity of the operation is 500 tons of mica-schist per month. The ground mica is used mainly in roofing, foundry facings and as artificial "snow" for decorations. Keeping pace with building requirements, sand and gravel was produced as usual in the vicinity of El Centro and Brawley.

The largest single mining operation in the county is that of the United States Gypsum Company operating on the northwestern edge of Fish Mountain, 26 miles northeast of Plaster City. The gypsum deposit is about 3 miles in length and 1 mile in width and is said to have the most uniform grade of any gypsum deposit in the United States, averaging 95 percent.[34] Open-pit mining methods are used. The ore is loaded into side-dump cars and hauled over the company's own railroad to the plant at Plaster City. This plant, operated originally by the Pacific Portland Cement Company, was enlarged, and a wallboard manufacturing unit was added during the year. The productive capacity on plasters was approximately doubled, and wallboard was produced late in 1947.

R.M.S.

Table 17. Mineral production from Imperial County during 1947

Product	Quantity	Value
Sand and gravel	232,704 short tons	[1]
Unapportioned (crude gypsum, scrap mica, and sand and gravel)		$907,843
Total value		$907,843

[1] Value included with "Unapportioned."

INYO COUNTY

General Geologic Features. Inyo County, with an area of 10,224 square miles, is the second largest county in California and contains both the highest and lowest points in the United States. Mount Whitney, elevation 14,501 feet, is the highest, and Salt Flat in Death Valley is the lowest, at an elevation of 280 feet below sea level. The main divide of the Sierra Nevada is the west boundary of the county. The major portion of the county is in the Basin Range geomorphic province. This province is an area of interior drainage, and the roughly parallel ranges alternating with basins and troughs are controlled by typical fault-block structure.

[33] Bransford, J. C., Imperial carbon-dioxide gas field: California Div. Mines Rept. 38, pp. 198-201, 1942.
[34] Sampson and Tucker, op. cit.

Owens Valley is a trough of tectonic origin whose floor has subsided along a series of parallel faults.[35] It is partly filled by Tertiary and Quaternary sediments. The White-Inyo Range to the east is built up of a thick, complexly faulted and folded series of sedimentary rocks ranging in age from Triassic to Lower Cambrian, with volcanics of Triassic age. All of these have been intruded by igneous rocks, predominantly granitic in character.[36]

Summit portions of some of the ranges, the Sierra Nevada, Coso, Argus, and Panamint, have areas of low relief which appear to be remnants of a single old-age erosion surface which extended across the entire region prior to the early or middle Pleistocene range-forming fault movements.[37] The latter three ranges are composed mostly of pre-Tertiary rocks, with a thickness of over 45,000 feet of pre-Cambrian metasediments and Paleozoic limestones, dolomites, shales, and quartzites. Intrusions, ranging from granite to gabbro, occurred during the Jurassic Nevadan orogeny.

Death Valley, at least in the southern part, is thought to be a syncline modified by normal faulting rather than a graben.[38] This area contains rocks of all the great geologic time divisions, Archean through Quaternary, with an aggregate thickness of 30,000 feet for the stratified rocks alone.[39] Folding and faulting has been on a grand scale, and some features associated with large, middle or late Tertiary thrust faulting appear to be without counterpart in North America. The largest of these thrusts is the Amargosa thrust, found in the Tecopa area in the southeast portion of the county.[40]

Mineral Resources. Inyo County has produced in excess of 125 million dollars worth of metallic and nonmetallic mineral products since 1880, and unrecorded production of lead, silver and gold would increase this figure. Production of the five major metals, lead, silver, gold, copper, and zinc has accounted for nearly one-third of the total value. The county also has produced considerable tungsten ore and minor amounts of antimony, manganese, molybdenum, and quicksilver ores. Important nonmetallic materials have been soda products, borates, talc, clays, and recently pumice. Other mineral products which have been exploited are asbestos, barite, limestone and marble, dolomite, gypsum, sulfur, and slate.[41]

The lead-silver-zinc deposits are probably the most important metallic deposits in the county, and the earliest mining here was that of the lead-silver ores in the southern part. Five districts have been most productive. These are the Cerro Gordo, Darwin, Tecopa, Modoc, and Slate Range districts. In the Darwin district (which also produced tungsten ore during the war) most of the lead-silver ore is enclosed in lime-

[35] Knopf, A., and Kirk, E., A geologic reconnaissance of the Inyo Range and the eastern slope of the southern Sierra Nevada, California, with a section on the stratigraphy of the Inyo Range: U. S. Geol. Survey Prof. Paper 110, 130 pp., 1918.

[36] Knopf, A., Mineral resources of the Inyo and White Mountains, California: U. S. Geol. Survey Bull. 540, pp. 81-120, 1914.

[37] Hopper, R. H., Geologic section from the Sierra Nevada to Death Valley, California: Geol. Soc. America Bull., vol. 58, pp. 393-432, 1947.

[38] Noble, L. F., Structural features of the Virgin Springs area, Death Valley, California: Geol. Soc. America Bull., vol. 52, pp. 941-1000, 1941.

[39] Noble, L. F., Rock formations of Death Valley, California: Science, vol. 80, pp. 173-178, 1934, no. 2069.

[40] Mason, J. F., Geology of the Tecopa area, southeastern California: Geol. Soc. America Bull., vol. 59, pp. 333-352, 1948.

[41] Tucker, W. B., and Sampson, R. J., Mineral resources of Inyo County, California: California Div. Mines Rept. 34, pp. 368-500, 1938.

silicate rocks, and consists of argentiferous galena with its oxidation products and lesser amounts of sphalerite, pyrite, and chalcopyrite.[42] The Cerro Gordo district has been the largest producer of lead, silver, and zinc ores in the state, but production has been very little in recent years.

Gold has been produced from the Argus, Panamint, and Inyo Ranges, and Sierra Nevada, but major activities have been curtailed since the war. Copper is produced principally from the concentrates of the silver, lead, and zinc operations.

Tungsten occurs principally in the Pine Creek area of the Sierra Nevada and in the Tungsten Hills west of Bishop. This general area is one of the few known localities in the world where scheelite occurs in commercial quantities in contact metamorphic deposits. The ore occurs in limestone bodies which are parts of roof pendants projecting into the granitic rocks.

Soda ash and trona are produced from Owens Lake. Borax mining from the colemanite beds in the Black Mountains east of Death Valley was active until 1926. Considerable talc is produced from this county, and the area around Talc City near Darwin is a major source of steatite talc, used in the manufacture of high-frequency insulators.[43]

Significant Activities During 1947. Major metal-mining activities during the year were limited to lead-silver-zinc and tungsten ores. The Anaconda Copper Mining Company continued their operations at Darwin, developing and mining the old Defiance, Independence, Thompson, and Bernon properties. Using the Radiore tunnel as their main haulage level, they continued production at a rate to give a 2-year average of 75 tons of shipping grade and 150 tons of milling grade ore per day. The milling ore required flotation of the primary sulfide lead and silver minerals and subsequent sulfidization and flotation of the oxidized minerals. Plans were going ahead for a larger capacity mill to operate on an all-sulfide ore to produce lead and zinc concentrates. Development work was extensive and included considerable diamond drilling. This company also took over the Shoshone mines from the Finley Company at Tecopa during the year and continued development on the Columbia No. 2 and War Eagle claims. Numerous lessees were active on lead properties throughout the county, and the Enterprise Mining Company continued exploration work on the Cerro Gordo mine.

The United States Vanadium Corporation continued work on their Pine Creek mine, which is reported to be the world's largest tungsten mine, and which constitutes the largest reserve of scheelite ore in the United States. Mined from an elevation of 10,000 to 12,000 feet, the ore is transported via a three-section aerial tramway to the mill at an elevation of 7,700 feet. The 1,500-ton mill produces in addition to scheelite, molybdenum and copper concentrates, the latter containing some silver and gold.

The Sierra Talc and Clay Company operations at Talc City continued with production of steatite-grade talc used in the manufacture of high-frequency insulators. In addition to their talc operations, this company increased production of the bleaching clay from their deposit east of Olancha. The clay is mined by the room-and-pillar method with

[42] Kelley, V. C., Geology and ore deposits of the Darwin silver-lead mining district, Inyo County, California: California Div. Mines Rept. 34, pp. 503-562, 1938.

[43] Wright, Lauren A., California talcs. Preprint of paper presented before Los Angeles Fall meeting of Am. Inst. Min. Eng., 8 pp., October 15, 1948.

slushers. It is used principally in the decolorizing and filtering of animal and vegetable oils. Numerous other talc deposits were mined throughout the county and accounted for a considerable portion of the state's total talc production. Pyrophyllite was processed by a grinding plant at Laws.

Three companies, the Natural Soda Products Company at Keeler and Permanente Metals Company and Pittsburg Plate Glass Company near Cartago, produced soda ash and trona from the brines of Owens Lake. Boron minerals were also produced from these brines.

Some sulphur was mined from the Last Chance Range east of Big Pine and was ground for use as a soil conditioner. Dolomite was quarried and ground for roofing granules by the Inyo Marble Company operating just north of Keeler. Pumice, sand, and gravel, were produced from several areas for the building industry. R.M.S.

Table 18. Mineral production from Inyo County during 1947

Product	Quantity	Value
Copper	232,000 pounds	$48,720
Gold	1,974 troy ounces	69,090
Lead	8,990 short tons	2,589,120
Silver	1,235,998 troy ounces	1,118,578
Stone	69,320 short tons	118,471
Sulfur ore	698 long tons	9,074
Talc and pyrophyllite	30,444 short tons	482,007
Zinc	702 short tons	169,884
Unapportioned (boron minerals, raw clay, diatomite, fuller's earth, molybdemum, pumice, sand and gravel, sodium salts, and tungsten concentrates)		1,991,524
Total value		$6,596,468

KERN COUNTY

General Geological Features. Kern County, containing 8,003 square miles, is in the south-central portion of the state. Its western boundary line is along the east slope of the Coast Ranges; its southern boundary crosses the Tehachapi Mountains and continues some 50 miles into the Mojave Desert; its eastern boundary is wholly within the desert; and its northern boundary crosses both the Sierra Nevada and the San Joaquin Valley. The Kern River and Poso Creek drain the west slope of the Sierra Nevada. These streams flow into the San Joaquin Valley where the water is used largely for irrigation. The eastern portion of the county contains a number of small basins of interior drainage, the principal ones being the Salt Dry Lake, Muroc Lake, and Rosamond Lake.

Five geomorphic provinces extend into the county, the Coast Ranges on the west, Mojave Desert on the east and south, Basin Ranges on the northeast, Sierra Nevada and the Great Valley of California in the central and northern portions. The Great Valley (here called the San Joaquin Valley) lies between the Coast Ranges on the west and the Sierra Nevada on the east. It is an alluvial plain whose western border is underlain by east-dipping Cretaceous and Cenozoic strata. The eastern border joins the Sierra Nevada whose westward-sloping bedrock dips under the alluvium and the Tertiary and Cretaceous sediments of the valley plain.

The great oil fields of the county have been developed principally along the margins of the Great Valley. The Sierra Nevada is terminated on the south by the Garlock fault which here marks the northern boundary of the Mojave Desert province. The core of the Sierra Nevada consists of Jurassic granitic rocks. Here at its southern end occasional patches of pre-Cretaceous metamorphics are exposed in the main mass of the range. To the west the bedrock dips under the sediments of the San Joaquin Valley. To the east, it is either flanked by its own alluvial fans or by Tertiary and Quaternary volcanics. The portion of the Mojave Desert province within the county lies in the wedge formed by the junction of the southeastward-trending San Andreas fault and the Garlock fault which extends northeasterly along the foot of the El Paso Mountains. This desert area is an alluvial plain studded with isolated buttes and bordered on the west by the Tehachapi and El Paso Mountains. These buttes consist largely of Jurassic granitic rocks with some Miocene volcanics and nonmarine sediments.

Mineral Resources. The mineral production of Kern County is completely dominated by oil and natural gas. This production comes from pools in the foothills along the east, south, and west sides of the San Joaquin Valley. Since its inception in 1895 this industry has grown to gigantic proportions in Kern County, the total production through 1947 having been $2,208,553,000 worth of petroleum and more than $100,000,000 worth of natural gas.

Borates in the form of borax and kernite are mined in large quantities a few miles northwest of Kramer, a station on the Santa Fe Railroad. These extensive deposits occur interbedded with Tertiary shales in the southeastern desert area of the county. A large portion of the world's supply of these minerals is here produced. Cement is manufactured at Monolith from a limestone deposit a short distance northeast of the plant. Clays are excavated from the beds of dry lakes in the southeastern part of the county for use in oil-well mud. Kaolinized rhyolitic material is shipped from Jawbone Canyon for use in the ceramic industry. For many years silt from the floor of the San Joaquin Valley has been used in the manufacture of brick. Feldspar is produced from a pegmatite 2 miles northwest of Rosamond.

Gold-silver ores are perhaps most numerous in their occurrence although largely confined to the eastern portion of the county, where they occur in veins in almost every type of igneous rock there found. In recent years, until the beginning of the war, the combined annual production of gold and silver approximated $3,500,000.

Both gypsum and gypsite have been produced in the county but now only gypsite is being mined. There are several deposits of this material near the foot of the east slope of the Coast Ranges, where it has been extensively mined, notably in the vicinity of Lost Hills. It occurs also at the south end of Salt Dry Lake in the eastern portion of the county where, for a number of years, it has been excavated and shipped for use as a soil conditioner. Other deposits occur along Cottonwood Creek some 15 miles east of Bakersfield.

Salt has long been produced at Saltdale by solar evaporation of the brines of Dry Salt Lake.

Tungsten ores are widely distributed in the eastern portion of the county although production has practically ceased since the war. De-

posits have been worked in the Randsburg area, the Sierra Nevada, the Piute Mountains, and the Greenhorn Mountains.

Tin has been found on the Tejon Ranch in the Tehachapi Mountains, but production has been negligible.

Volcanic ash (pumicite) forms extensive beds in El Paso Mountains where it was mined for use in Old Dutch Cleanser until the fall of 1947.

Other minerals occurring in the county which have either had some production or are believed to have commercial possibilities include antimony, arsenic, asbestos, copper, iron, lead-silver, lead-zinc, limestone, onyx, perlite, pumice, quicksilver, and rose-quartz.

Significant Activities During 1947. The Pacific Coast Borax Company continuously operated its mine at Boron, a few miles northwest of Kramer near the southeastern corner of the county.

The Monolith Portland Cement Company's plant at Monolith operated continuously during the year.

Antelope Materials Company (Macco Construction Company), Mojave Corporation and O. L. Riley Company continue to ship rotary mud for oil-well drilling from Muroc and Rosamond Dry Lakes.

Gypsite for agricultural use was produced in large quantities in the San Joaquin Valley, H. M. Holloway, Inc., of Lost Hills being the principal producer.

Tropico Mines, Burton Bros., Inc., continued operation of their gold mine and mill west of Rosamond on a curtailed basis. The Cactus Queen mine was leased to this company and the ore remaining in the property will be extracted and treated in the Tropico mill.

The mineral resources of Kern County have been more fully described in a recent report of the Division of Mines.[44]

R.J.S.

Table 19. Mineral production from Kern County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[1]
Clay, raw	213,475 short tons	$746,372
Gold	6,228 troy ounces	217,980
Gypsum, crude	[2]352,977 short tons	[2]558,269
Natural gas	86,289,000 M. cu. ft.	8,329,000
Natural gasoline and allied products:		
Natural gasoline	135,140,000 gallons	6,766,000
Liquefied petroleum gases	91,600,000 gallons	3,571,000
Petroleum	106,048,000 barrels	176,360,000
Sand and gravel	608,674 short tons	671,917
Silver	7,686 troy ounces	6,956
Unapportioned (boron minerals, cement, pumice, salt, silica [quartz], stone, and tungsten concentrates)		11,218,422
Total value		$208,445,916

[1] U. S. Bureau of the Census not at liberty to publish figure. Value not included in county total.
[2] A small quantity of crude gypsum produced in Kings County is included with Kern County.

KINGS COUNTY

General Geologic Features. Kings County lies at the southern end of San Joaquin Valley, and nearly all of its area is occupied by valley

[44] Tucker, Sampson, and Oakeshott, Mineral resources of Kern County: California Jour. Mines and Geology, vol. 45, pp. 203-298, 1949.

alluvium, so that little geology is to be seen at the surface. An exception is the southwest corner of the county, where a series of sediments is exposed, and where Pleistocene, Pliocene, Miocene, Eocene, and Cretaceous strata may be seen. Drilling for petroleum has shown that a similar series exists below the alluvium of the valley. From a standpoint of mineral production, the outstanding geologic feature of Kings County is Kettleman Hills, a range 30 miles long and 5 to 6 miles wide, extending through Kings County and northwestward into Fresno County. These hills rise about 700 feet above the surrounding plains to an elevation above the sea of 1,400 feet. They have an anticlinal structure in Tertiary and probably Cretaceous strata and contain three domes, North Dome, Middle Dome, and South Dome. The trend of the South Dome is to the southeast toward the Lost Hills oil field of Kern County, and this is assumed to be a continuation of the same structure.

Mineral Resources. Petroleum and natural gas were discovered at Kettleman North Dome in 1928, and the field has been one of California's major producers of both these mineral substances since that date. The wells penetrate Pleistocene and Pliocene formations to reach six productive horizons in the Miocene and one in the underlying Eocene. Recent production of other minerals has been very small, although deposits of clay suitable for brick, fullers earth, gypsum, mineral paint, and quicksilver are found in the county. Total production of quicksilver has amounted to a little more than 2,000 flasks from two mines near the common corner of Kings, Fresno, and Monterey Counties.

Significant Activities During 1947. An outstanding development late in 1947 and early in 1948 was the completion of a successful oil well in the McAdams sand of Eocene age at Kettleman Middle Dome. Some gas accompanies the oil, but not as much as at Kettleman North Dome. The well was redrilled after tools had been lost in the hole to a depth of 12,281 feet, although at one time it was 12,389 feet deep and had penetrated the Eocene sand for 310 feet. C.V.A.

Table 20. Mineral production from Kings County during 1947

Product	Quantity	Value
Gypsum, crude	[1]	[1]
Natural gas	39,972,000 M. cu. ft.	$4,282,000
Natural gasoline and allied products:		
Natural gasoline	63,827,000 gallons	3,475,000
Liquefied petroleum gases	36,986,000 gallons	1,362,000
Petroleum	7,503,000 barrels	15,482,000
Total value		$24,601,000

[1] A small quantity of crude gypsum produced in Kings County is included with Kern County.

LAKE COUNTY

General Geologic Features. Lake County is situated within the northern Coast Ranges province, and except for the portion south of the southern half of Clear Lake, is almost entirely covered with Franciscan sedimentary rocks, mostly shales and argillaceous sandstone. An area along the west shore of Clear Lake, extending some 12 miles south from Kelsey Creek and inland for about 6 miles, is Pleistocene rhyolite. There are patches of Recent basalt near the southern end of the lake and in

areas north and south of Stubbs on the east shore of the lake. Narrow belts of serpentine and Tertiary volcanic rocks that trend northwestward occur in many places south of Clear Lake. There is a small area of Cretaceous rocks at the southern end of the lake. Beds of sand and gravel have been deposited at the mouths of the creeks emptying into the lake. The geology of Lake County is shown on maps prepared by Forstner,[45] and Smith,[46] and the volcanic history of the Clear Lake area has been discussed by Anderson.[47]

Mineral Resources. Borax has been produced from the beds of Borax Lake and Little Borax Lake near the south end of Clear Lake. Chromite has been mined from narrow stringers and small lenses in serpentine in areas west of Middletown and southeast of Lower Lake. A copper prospect showing azurite, malachite, and some sulphides occurs in limestone 4 miles northwest of Middletown. Gold and silver have been reported from assays of quartz samples taken from the Franciscan formation north of Upper Lake and west of Adams. Beds of limestone occur in the Franciscan formation in Burns Valley north of Lower Lake and near the Abbott quicksilver mine. Manganese minerals are found in lenses of chert in the Franciscan formation in many areas, and manganese has been mined from deposits north and west of Upper Lake, west of Middletown, and north of Hullville. Lake County is noted for the number and variety of mineral springs, which occur in many parts of the county. Some springs have been developed as resorts; the water is also bottled for sale. Cinnabar, metacinnabar, and native quicksilver occur in seams and fractures in brecciated Franciscan sandstones, cherts, and shales, and in the brecciated serpentine that intrudes them. Cinnabar is also found in shrinkage cracks in Pleistocene volcanic rocks covering crushed and brecciated sedimentary rocks. Most of the country rock is silicified. Much of the cinnabar is associated with pyrite, calcite, dolomite, and sulphur. Natural gas has been collected for local domestic use from seepages and shallow wells in the vicinity of Kelseyville and Lower Lake. Sand and gravel pits are worked along Kelsey Creek and the basalt tailing from the Sulphur Bank mine is used in the manufacture of concrete building blocks. Sulphur has been produced from cavities and seams in the volcanic rock formation at the Sulphur Bank mine. The mines and mineral resources of Lake County have been described by Averill.[48]

Significant Activities During 1947. Production of sand and gravel from deposits along Kelsey Creek increased during 1947. The material was used for roads and as concrete aggregate. Basalt rock mined from the waste dumps at the Sulphur Bank mine was crushed and screened for aggregate to be used in the manufacture of concrete building blocks. The Sulphur Bank and Great Western quicksilver mines were shut down during the year and their equipment was inventoried for sale. Mineral water was bottled for sale at three springs in Lake County (Bartlett Springs, Clearlake Oaks, and Witter Springs) during 1947. The resort buildings at Bartlett Springs were destroyed by fire during the year.

J.C.O.

[45] Forstner, William, The quicksilver resources of California: California Min. Bur. Bull. 27, 273 pp., 1903.

[46] Smith, J. P., op. cit.

[47] Anderson, Charles A., Volcanic history of Clear Lake area: Geol. Soc. America Bull. 47, pp. 629-664, 1936.

[48] Averill, Charles V., Lake County: California Div. Mines Rept. 43, pp. 15-40, 1947.

Table 21. Mineral production from Lake County during 1947

Product	Quantity	Value
Mercury	364 flasks	[1]
Sand and gravel	70,284 short tons	[1]
Unapportioned (mercury, sand and gravel, and stone)		$107,232
Total value		$107,232

[1] Value included with "Unapportioned."

LASSEN COUNTY

General Geologic Features. All of Lassen County, except a portion along the southern border, is covered with Tertiary volcanic rocks and Pleistocene lake beds. A narrow belt of acid intrusive rocks outcrops along the west shore of Honey Lake and extends southeastward along the border of the county from Johnstonville to Reno Junction. Small patches of granitic rocks also outcrop north and east of Westwood. The hills south and east of Mountain Meadows Reservoir are Carboniferous metavolcanics. The geology of Lassen County is shown on maps prepared by Smith.[49]

Mineral Resources. Copper prospects showing metallic oxides, sulfides, and some native copper disseminated in diorite, have been explored in the Mountain Meadows district and about 13 miles north of Doyle. Gold combined with silver occurs in veins and fractures in a shear zone in biotite-quartz diorite in the Diamond Mountain district, and in rhyolite breccia in the Hayden Hill district. Biotite-quartz diorite and a rhyolitic tuff are quarried from deposits in the Susanville area. Basalt rock is mined for use as a concrete aggregate from a quarry about 8 miles west of Susanville. Deposits of pumice and volcanic ash have been explored in the Susanville area. Perlite deposits occur in the volcanic rocks about 4 miles northeast of Wendel. Hot springs flow from volcanic rocks in the vicinity of Bieber and at Amedee. The mines and mineral deposits of Lassen County have been described by Averill and Erwin.[50]

Mineral materials produced in Lassen County during 1947 were gold, sand and gravel, silver, and stone.

Significant Activities in 1947. The cyanide plant of the Lassen Eagle Mining Company at Hayden Hill was remodeled during the year. Preparations were made to cyanide some of the old mine dumps and to mine shear zones on the surface with a power shovel. Some sorted gold ore from mine developments in the Diamond Mountain district was stock piled during the year. Basalt rock was mined west of Susanville and used for concrete aggregate.

J.C.O.

LOS ANGELES COUNTY

General Geologic Features. Los Angeles County, containing 4,071 square miles, is on the coast in the southwestern part of the state. Its terrain consists of a coastal plain bounded on the north by the Santa Monica Mountains and by ranges of hills extending southeastward to the

[49] Smith, J. P., op. cit.

[50] Averill, C. V., and Erwin, H. D., Mineral deposits of Lassen County: California Div. Mines Rept. 32, pp. 405-444, 1936.

Santa Ana Mountains. The San Fernando Valley lies between the Santa Monica Mountains and the San Gabriel Mountains to the north. North and east of the San Gabriel Mountains is the Mojave Desert. There are some 750 square miles of desert within the county boundaries. The Santa Clara, Los Angeles, and San Gabriel Rivers drain the western portion of the county. To the east the drainage is interior, in wet periods part of it going into Muroc and Rosamond Lakes.

Practically all of the county, with the exception of its desert area, lies within the Peninsular and Transverse Ranges geomorphic provinces, in part described by Jenkins [51] as follows:

"The Peninsular Ranges, separated by long intervening valleys, conditioned by erosion along faults which are active branches of the San Andreas system, trend northwest-southeast. This trend is characteristic of the Coast Ranges, but the geology, except that of the Los Angeles Basin, is more like that of the Sierra Nevada. The dominating rocks are granitic, having invaded an older metamorphic series . . .

"The Los Angeles Basin and the island group consisting of Santa Catalina, Santa Barbara, and the distinctly terraced San Clemente and San Nicolas Islands, are included in this province. The submarine topography in this island region indicates the presence of numerous fault scarps and troughs.

"The Los Angeles Basin is one of the most important oil districts in California. It is an area of deep Cenozoic marine deposition and contains a large number of prolific producers within a limited and highly populated area of 25 by 35 miles. Some of the fields extend westward under the sea . . ."

Many workers have contributed to the published accounts of the geology of Los Angeles County. However, the most complete summary of the county geology may be found in a compilation of articles published by the Division of Mines.[52]

Mineral Resources. Approximately 95 percent of the mineral production of Los Angeles County has been petroleum and natural gas. The remaining 5 percent included some 27 mineral substances—asphalt, barite, borax, clay, copper, dolomite, diatomite, feldspar, gems, gold, graphite, gypsum, iodine, lead, limestone, magnesium chloride, manganese, marble, mineral water, miscellaneous stone, potash, salt, silica, silver, sulfur, talc, titanium and zinc. Of these, clay (brick) and miscellaneous stone, which includes granite, crushed rock, rubble, paving blocks, sand, and gravel are by far the more important.

The first discovery of gold in California is believed to have been in Los Angeles County. While both the date and the locality of this discovery vary somewhat in different published reports, Cutter [53] says that it was either during the latter part of 1841 or the early part of 1842, and places it in San Feliciano Canyon some 35 miles northeast of Los Angeles. The recorded gold production from the county through 1947 has exceeded $2,250,000, more than half of which came from the Governor (New York) mine in the Mint Canyon area, some 30 miles north of Los Angeles. This quartz vein in quartz diorite was worked to a depth of approximately 1000 feet. Clays in the immediate vicinity have long been used in the manufacture of brick and pottery. At the present time there is only one producer of diatomite in the county, the Great Lakes Carbon Company. This company has recently acquired from the Dicalite

[51] Jenkins, Olaf P., Geomorphic provinces of California: California Div. Mines Bull. 118, p. 87, 1943.

[52] California Div. Mines Bull. 118 (Particularly Ch. VIII, Los Angeles Basin and Southernmost California, pp. 282-363), 1943.

[53] Cutter, D. C., The discovery of gold in California: California Div. Mines Bull. 141, p. 13, 1948.

Table 22. Mineral production from Los Angeles County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[1]$10,936,000
Clay, raw	477,011 short tons	436,146
Gold	48 troy ounces	1,680
Natural gas	95,702,000 M. cu. ft.	8,348,000
Natural gasoline and allied products:		
Natural gasoline	300,722,000 gallons	15,928,000
Liquefied petroleum gases	16,238,000 gallons	508,000
Petroleum	91,889,000 barrels	164,122,000
Sand and gravel	11,088,519 short tons	6,866,923
Silver	6 troy ounces	5
Stone	4,284,150 short tons	3,167,650
Unapportioned (cement, diatomite, iodine, lime, silica [quartz], and soapstone)		3,386,229
Total value		$202,764,633

[1] According to U. S. Bureau of the Census. Value not included in county total.

Company the deposit in the Palos Verdes Hills between Redondo Beach and San Pedro. The diatomite is interbedded with clay. The clay overburden ranges from practically nothing to 10 feet in thickness. Formerly a deposit on the north slope of the San Jose Hills, 2½ miles east of Covina was operated by the Featherstone Insulation Company.

There are several deposits of graphitic material in the county, notably in the Verdugo Hills north of Glendale and in the Bouquet Canyon area of the San Gabriel Mountains. At different times three plants for the concentration of this material have been operated. No production is being made at the present time. Iodine is extracted from waste water of oil wells in the Venice, Seal Beach, Inglewood, and Dominguez oil fields. One plant is operating in each field.

Deposits of lead-silver and zinc occur in a belt of hornblende schist on Catalina Island, 14 miles by road northwest of Avalon. The deposits were mined by the Santa Catalina Island Mining Company for some 10 years, beginning about 1919.

Owing to the rapid growth of Los Angeles and the surrounding suburban cities, miscellaneous stone, including crushed rock, sand, and gravel, has become an important factor in the mineral resources of the county. The plants are situated along the Los Angeles River, in the San Fernando Valley, and the San Gabriel River and the Rio Hondo in the San Gabriel Valley. As stated above, approximately 95 percent of the imposing total of mineral production from the county has been petroleum and natural gas. This production has come from 31 separate fields and a few wells in isolated areas, none of which developed into an oil field.

Salt has been produced by the evaporation of sea water in Long Beach. Deposits of titaniferous iron ore occur south of Soledad Canyon, and as a result of erosion, placer deposits of this material are found in the canyons and washes of the area. During 1947 research was conducted on these placer deposits to determine the feasibility of producing a titanium concentrate suitable for manufacturing paint pigment.

Significant Activities of 1947. The county's most important industry, the production of oil, proceeded as usual, the 1947 output of petroleum exceeding that of 1946.

The Great Lakes Carbon Company, after much research, built a plant at Torrance for the expansion of perlite to be used as insulation. Research on the titaniferous iron ores of the San Gabriel Mountains gave some promise of future development. The tremendous building program in the City of Los Angeles and the county has kept the sand and gravel plants busy, and this industry appears to be in a very healthy condition.

R.J.S.

MADERA COUNTY

General Geologic Features. Madera County extends northeastward from the center of San Joaquin Valley to the summit of the Sierra Nevada, with all the diversity of climate and resources this implies. It is bounded on the south most of the way by the San Joaquin River, which turns north to also form the western boundary. Fresno River and smaller streams draining the western half of the county generally carry little water in their lower courses in the dry season.

The southwestern third of the county is in the nearly flat, alluvium-covered valley. It is bordered on the east in the lower foothills by a band of marine sediments tentatively mapped as upper Eocene. These trend northwestward and have a width of only 1 to 3 miles. In the northern part of the county, the Upper Jurassic metasedimentary rocks extend about 12 miles into the county along the east side of the Eocene formations.

Southward along the west slope of the Sierra Nevada, more of the granitic batholith is exposed. The granite is in contact with the Eocene beds in the south half of the county and also adjoins the Mariposa rocks on the east. From there to the summit granite is the principal rock exposed. Some areas of undifferentiated pre-Cretaceous are known. In the higher mountains near the east boundary, there is a large area of Jura-Trias altered volcanics, and several small bodies of younger volcanic rocks, some as young as Quaternary. A feature of interest in that region is the Devil's Post Pile, Quaternary basalt in which columnar jointing is well developed. This area is a National Monument. The older folded and altered sediments and volcanics are in part overlain by the later volcanic eruptives. The geology of the region, known as the Minaret district, has been covered in detail by Erwin.[54] A recent report by Trask and Simons [55] describes the Minaret magnetite deposits. Knowledge of the underground geology of the county has been increased since 1934 by drilling records of companies searching for oil and gas.

Mineral Resources. As Madera County was not established until 1893, it has not been credited with mineral production prior to that year. This early output was principally gold, silver, and copper.

In the valley section, one of the county's more valuable mineral resources, natural gas, has been found and partially utilized only in the past 14 years. In 1934, the Chowchilla gas area was discovered by Pure Oil Company on the old Chowchilla Ranch about 12 miles southwest of Chowchilla.[56] The discovery well, No. 1 "Chowchilla" in sec. 7, T. 10 S.,

[54] Erwin, Homer D., Geology and mineral resources of northwestern Madera County, California: California Div. Mines Rept. 30, pp. 7-78, 1934.

[55] Trask, Parker D., and Simons, Frank S., Minarets magnetite deposits of Iron Mountain, Madera County, California: California Div. Mines Bull. 129, pp. 117-128, Map, 1948.

[56] Hodges, F. C., Chowchilla gas area: California Div. Oil and Gas, Summary of Operations, California Oil Fields, vol. 29, no. 2, pp. 7-11, 1943.

R. 14 E., was drilled to a depth of 8,399 feet, striking quartz diorite of the Bedrock complex at 8,394 feet. Dry natural gas of low calorific value was found 7,925 feet below the surface in an Upper Cretaceous sand 140 feet thick. The Zilch gas zone was found in No. 2 "Chowchilla" well between 2,400 and 2,700 feet in depth, in middle Miocene nonmarine shale with minor sand lenses. The gas in this zone has a calorific value more than twice that of the deep zone. The estimated productive area of Chowchilla natural-gas field is 2,378 acres; reserves are estimated to be 20,051,000 thousand cubic feet of dry natural gas in the Zilch zone.

In 1943, the Gill Ranch gas field was discovered by The Texas Company. This is about 16 miles southwest of Madera, near San Joaquin River. Well No. "Gill" 38-16 was drilled to a depth of 9,154 feet into the bedrock complex, on sec. 16, T. 13 S., R. 16 E.[57] Good gas was found as deep as 5,760 feet, but production was established in Eocene sand between 4,419 and 4,485 feet. The estimated reserve of dry natural gas at the Gill Ranch gas field was 33,517,686 thousand cubic feet as of July 1, 1947.[58] The same company in 1943 also found gas on the Moffatt Ranch 7 miles northeast of Firebaugh at a depth of 3,930 feet in Eocene sand.

Pumice and volcanic ash in small areas north and northwest of Friant have been utilized only in recent years. They are probably later than the upper Eocene sediments, which they border on the east. They are now important items of mineral production.

Copper was mined as early as the sixties in the vicinity of Daulton, on the foothill copper belt in the Upper Jurassic amphibolite schist, and both north and south of Daulton, from the Mariposa County line to Fresno River. Copper prospects have also been noted in the higher mountains, in the Minarets and Mount Raymond districts.

Granite was produced in large quantities for more than 40 years from quarries at Raymond. The total value of the output, probably about $10,000,000, was greater than that of any other mineral product from the county. The stone was noted for its fine quality, light color, and workability.

Gold-quartz ores were found at or near contacts of the granite and pre-Cretaceous slate and schist which cross the county through Grub Gulch to Hildreth on the south. Little gold mining has been done in recent years, though several quartz mines had substantial production records years ago, some of them before the county was created.

Silver, lead, and zinc ores occur in Mount Raymond district, where the Star mine (now included in the Smith-Bradford group) was worked in a small way in 1888-90. In the Minarets district, gold, silver, zinc, and copper have been found and considerable work has been done. Both localities are in the high mountains.

In addition to the Minarets deposits, iron ore is found in the Mount Raymond district. These deposits are undeveloped, although the Minarets deposit was drilled by the U. S. Bureau of Mines during the last war.

Tungsten ore was produced from several deposits during the last war, and work was done on many more. All contained scheelite except one in which hübnerite was found. The deposits occur in the mountains where granite has been in contact with limestone. The Strawberry mine

[57] Kaplow, E. J., Operations in District 5, 1943: California Div. Oil and Gas, Summary of Operations, California Oil Fields, vol. 29, no. 2, p. 68, 1943.

[58] Bush, R. D., and others, Summary of operations, California oil fields: California Div. Oil and Gas, vol. 33, no. 1, 1947.

near Jackass Meadows was the leading producer and continued operation longer than most.

Other minerals, prospected but not known to have been produced commercially, include asbestos, magnesite, marble, molybdenite, cobalt, nickel, silica, and soapstone.

Common brick was made years ago in a plant at Madera. Sand and gravel are produced for local use. A commercial sand plant was operated in the 1920's on Cottonwood Creek 5 miles southeast of Madera.

Significant Activities During 1947. The production of pumice to use with portland cement in making light-weight building bricks and other concrete products was carried on actively in 1947. Volcanic ash (or pumicite) was also produced. The demand for pumice bricks for dwellings in central California increased decidedly, and resulted in sales of pumice to many customers outside the county. Several firms are also making the bricks locally. Shipments are made mostly by truck.

Elmer Erickson produces and processes pumice from a deposit 1 mile north of Friant both for use in his own brick plant and for sale to others. Pumice is dug with a rooter pulled by a tractor, and crushed, screened, and elevated to a bin from which trucks are loaded. At the brick plant half a mile away, three sizes of bricks were being made during 1947.

Pacific Pumice Materials Company operates a deposit on the Goble land about 14 miles east of Madera near San Joaquin River and make pumice-concrete brick. California Pumice Aggregate Company, Pumice Industries and David Smith all operated part of the year, producing pumice aggregate for sale in the area 1 to 2 miles north and northwest of Friant. Pumice Industries and California Industrial Minerals Company (Forrest S. Taylor) produced white pumicite in the same district. Other firms in the county which purchased pumice and pumicite from the above producers for use in brick, tile, and concrete pipe are El Rancho Building Tile Company, San Joaquin Pipe and Construction Company, and Chowchilla and Rogers Materials Company, Madera.

Eleven dry natural gas wells were in condition to produce at the beginning of the year. The Texas Company has six wells in the Gill Ranch field, Shell Oil Company four wells, and Natural Gas Corporation of California one well. Most of the production came from the Gill Ranch field; the wells of the Chowchilla gas-bearing area had not yet been connected up for production.

Production of gold was reported as $6,895, which came principally from small suction dredges. C.A.L.

Table 23. Mineral production from Madera County during 1947

Product	Quantity	Value
Gold	197 troy ounces	$6,895
Pumice	17,080 short tons	[1]
Silver	57 troy ounces	52
Unapportioned (natural gas, pumice, stone, and tungsten concentrates)		230,125
Total value		$237,072

[1] Value included with "Unapportioned."

MARIN COUNTY

General Geologic Features. Marin is the peninsular county whose southern extremity forms the northern boundary of the Golden Gate. A rugged and picturesque topography has been carved in its hills and northwest-trending ridges which culminate in Mount Tamalpais (2,604 feet), sloping westward to the ocean and eastward to the bay of San Francisco. Subsidence has created numerous drowned valleys and small harbors on the bay side of the peninsula.

Geologically, Marin County is divided into two parts, namely, the mainland and the Point Reyes peninsula. They are separated by the San Andreas fault zone, which strikes northwestward. The mainland, east of the fault, comprises about three-quarters of the land area of the county. Throughout most of this area rocks of the Franciscan formation of Jurassic age are exposed on the surface. They consist of sandstones, shales, limestone lenses, chert, glaucophane schists, associated basic igneous rocks such as diabase, and ultrabasic instrusives of peridotite altered to serpentine. In the northwestern corner of the county the Franciscan formation is overlain by the marine Merced formation of Pliocene age. The Merced is made up of sandstone, conglomerate, clay shales, and some interbedded tuff. There are patches of Sonoma volcanics (Pliocene)[59] in the northeastern corner of the county. These exposures include tuffs, andesite, and basalt.

Emerging from the Pacific Ocean in a series of wave-cut terraces, the Point Reyes peninsula rises gently eastward to a long straight ridge adjoining the San Andreas fault. Throughout the southwestern part of the peninsula middle Miocene marine sandstone and shale of the Monterey group outcrop. These sediments are in contact with granite which is exposed in the northeastern part of the peninsula.

The locus of the San Andreas fault is in a zone of recurrent faulting which separates the Point Reyes from the Marin peninsula. The strike of this zone is northwest, and is expressed topographically in the rift valley of Tomales Bay (1 mile wide and 15 miles long), and Bolinas lagoon. In the movement which occurred along this fault in 1906, the horizontal component, reaching a maximum of 21 feet, greatly exceeded the vertical component.

Mineral Resources. Large resources of miscellaneous stone, common clay suitable for brick and tile, ordinary sand, and limestone exist in Marin County. Both crushed rock and clay have been produced regularly for many years, but neither the dune sands on Point Reyes nor the extensive limestone deposits near Point Reyes Station have been used in recent years. One limestone deposit is within the granodiorite half a mile east of Point Reyes Station, and the other is a limestone member of the Franciscan midway between Point Reyes Station and Bolinas. Both deposits have been described by Eckel.[60]

Small deposits of manganese oxide are associated with the chert lenses in areas covered by Franciscan rocks. During World War II one such deposit south of Novato was mined.

During World War II a quicksilver deposit 8 miles west of Petaluma was prospected, but no quicksilver was produced.

[59] Dickerson, Roy E., Tertiary and Quaternary history of the Petaluma, Point Reyes, and Santa Rosa quadrangles: California Acad. Sci. Proc., 4th ser., vol. 11, no. 19, pp. 527-601, 1922.

[60] Eckel, E. C., Limestone deposits of the San Francisco region: California Div. Mines Rept. 29, pp. 353, 356, 1933.

Wells have been drilled for petroleum near Duxbury Point where seepages of oil and gas have been found. Two wells drilled to 6,000 feet during 1947 encountered a tar sand in the Monterey formation. The petroleum possibilities of this region have been discussed by Douglas.[61]

Significant Activities During 1947. Aggregate is produced by the Marin Gravel Company from Franciscan chert on Lagunitas Creek 2 miles east of Point Reyes Station. The pit is on the south side of Black Mountain, and the crushing and screening plant is on the hillside below the pit level. The broken rock is crushed in two stages and sorted on screens into five sizes. A washing plant and an asphalt plant are on the property.

The Hutchinson Company produces crushed rock and riprap at a plant near the Green Brae Station. Two large pits have been opened in an altered sandstone of the Franciscan group. The large crushing plant is equipped to produce seven sizes from dust to 2¼ inches, and also riprap. These materials are loaded on trucks, cars, or barges.

The Basalt Rock Company has built a plant at McNear's Point to furnish riprap, which is used in the construction of jetties. A massive altered sandstone is obtained from two pits nearby. The crushing plant is designed to produce a minimum of fines. Material smaller than 3 inches is stock piled pending installation of a secondary crusher. All shipments are by water. Barges are loaded by truck or by a belt conveyor.

The McNear Brick Company produces the light-weight aggregate Haydite as well as common brick at a plant at McNear's Point.

W.E.V.P.

MARIPOSA COUNTY

Geologic Features. Mariposa is one of the mountain counties of California whose boundaries fall entirely within the Sierra Nevada geomorphic province. The famous Yosemite Valley with its glacial sculpturing and the magnificent Mariposa Grove of Big Trees are two examples of a great wealth of natural phenomena present in the county. The rugged canyon of the Merced, of which Yosemite Valley is a glaciated part, and the glaciated Cathedral Range lying at the eastern border of the county are the two most prominent topographic features. The Merced River canyon crosses almost the entire width of the county and is one of the major river systems of the Sierra Nevada.

A majority of the rocks outcropping in Mariposa County belong to the Bedrock or subjacent series and are of Jurassic and Upper Paleozoic age. Tertiary and other post-Jurassic rocks have largely been stripped from the Bedrock series by erosion. Sparse remnants of late Tertiary and Pleistocene volcanics remain in the northeast-central part of the county, associated with even more scanty remnants of early Tertiary auriferous gravels, the eroded segments of ancient river channels which were once buried beneath later Tertiary eruptive rocks.

Granitic rocks of Upper Jurassic age form most of the bedrock from the vicinity of El Portal eastward to the Cathedral Range which lies on the eastern boundary of the county. A very broad, irregular belt of Upper Paleozoic metasediments assigned to the Calaveras formation by Turner and Ransome [62] crosses the county in a northwestward direction

[61] Douglas, J. M., Duxbury Point region: California Div. Mines Bull. 118, p. 621, 1943.

[62] Turner, H. W., and Ransome, F. L., U. S. Geol. Survey Geol. Atlas, Sonora folio (no. 41), 1897.

between El Portal and the town of Mariposa. West of this belt is a similarly trending series of tightly folded metamorphosed sediments, volcanics, and basic intrusives of Upper Jurassic age belonging to the Mariposa and Amador formations. Local intrusions of granodiorite and related acid and intermediate igneous rocks disrupt the Bedrock structures in the western part of the county. These postdate the invasions of basic and ultrabasic intrusives.

The Mother Lode mineralized fault zone diagonally traverses Mariposa County passing through the towns of Bagby, Bear Valley, Mount Bullion, and Mariposa. Although the southern part of this zone was not so strongly mineralized as the central part in Amador County, it is nonetheless an important economic belt, Mariposa County having been identified with gold mining throughout its history. The zone terminates in massive granodiorite in the vicinity of Mormon Bar, a short distance south of the town of Mariposa.

Mineral Resources. Although Mariposa is primarily a gold-mining county, gold is by no means the only mineral product mined in quantity. Substantial reserves of copper ore still remain in the foothill copper belt, principally in Hunter Valley and at the Green Mountain mine north of Raymond. Small bodies of chrome ore occur in the serpentine of the county, which have been exploited during wartime. Most of these are too small and too low in contained Cr_2O_3 to compete with foreign ores in normal markets. The deposits are located southeast of Coulterville along the Bagby grade. Zinc and lead have been mined in considerable quantity over a long period of years. The Blue Moon mine in the Hornitos district has been the principal producer during the last decade. Zinc production in Mariposa County reached a peak of 6,688,000 pounds in 1944. Lead was produced with the zinc in proportion of about 1 to 26 for a peak production of 255,657 pounds in 1944. The zinc-lead properties are now idle. Numerous small deposits of siliceous manganese ore were exploited during World War II. The ore occurs principally in sedimentary cherts of Upper Jurassic age. Manganese mining, like chrome mining, is purely a wartime operation in Mariposa County because of the grade of the ore and prohibitive costs of selective mining of the small ore bodies. The considerable silver production of Mariposa County through the years has been recovered mainly as a byproduct of gold mining. A few properties have been worked primarily for silver in the Bootjack district 6 miles southeast of the town of Mariposa.

In the field of nonmetallic minerals, barite, mica schist, slate, silica, and talc are the principal resources. The barite deposits of El Portal district have produced the largest tonnages of barite and witherite thus far recorded in the state. Peak production was in 1944. Large reserves of mica schist suitable for use on asphalt roofing and in the rubber-tire industry occur along Mariposa Creek east of Indian Gulch. The rock has been mined for such purposes from time to time in the past. Silica in the form of vein quartz is present in enormous quantities in the foothills of the Sierra west of the Mother Lode. Many of the veins are barren of sulfides and most other impurities and are suitable for acid fluxes in steel manufacture, for ferrosilicon, and possibly for glass. Large tonnages were marketed for manufacture of ferrosilicon during the last World War. Silica is an important resource of Mariposa County to which far too little attention has been paid by industry. Talc occurs as a hydro-

thermal alteration product of serpentine in the fault zones of the Mother Lode. Massive talc was once popular for building facings in the gold country and may conceivably become economically important as a ceramic material. Unlimited quantities of black slate occur in many parts of western Mariposa County. This slate has been mined intermittently on a small scale for various purposes for many years. The accessible quarries could rapidly produce material suitable for flagstones, roofing slate, and roofing granules if sufficient demand should arise.

Mining Activities for 1947. Metal mining almost came to a halt in Mariposa County during 1947. The Mount Gaines gold mine was the only large operation which remained active throughout the year. It is situated near Hunter Valley in the Hornitos district in the western part of the foothill gold belt. The mine was producing about 100 tons of ore per day in the middle of the year. Small tonnages of ore were shipped from development or exploratory work at gold mines from many districts. Mines which produced small intermittent tonnages were: June Ann, Odgers, and Schroeder group, Midpines district; Combination and Specimen, Bagby district; Hasloe, Coulterville; Gold Star, Mariposa; and Saint Gabriel and Pendola Garden, Hornitos district. Considerable tonnages of placer gravel were washed at Kinsley and at the Upper Bear Creek placer. A little copper ore was shipped from the Barrett mine in Hunter Valley. A few thousand tons of river gravel are mined each year by Mariposa County and the Yosemite National Park for road metal, but no large aggregate plants are operating at present within the county. Baroid Sales Division of National Lead Company produced barite from its El Portal properties for a short time during the year. The mines are now idle. O.E.B.

Table 24. Mineral production from Mariposa County during 1947

Product	Quantity	Value
Copper	4,000 pounds	$840
Gold	6,363 troy ounces	222,705
Silver	1,933 troy ounces	1,749
Unapportioned (barite, sand and gravel, and stone)		76,644
Total value		$301,938

MENDOCINO COUNTY

General Geologic Features. Mendocino County, situated in the northern Coast Ranges and bordering on the Pacific Ocean, is almost entirely covered with argillaceous sandstones, conglomerates, cherts, shales, and other rocks of the Franciscan formation. A belt of Cretaceous conglomerate, sandstone, and shale about 10 miles wide, occurs along the coastline, and small remnants of Cretaceous and Tertiary sedimentary formations are found in the interior. Extensive areas of serpentine outcrop in the northern part of the county in the vicinity of Big Red Mountain and in the northeast corner of the county, but no granitic intrusive rocks have been noted. The geology of Mendocino County is shown on the map prepared by Smith.[63]

[63] Smith, J. P., Geologic map of the State of California, California Min. Bur., 1916.

Mineral Resources. Carbon dioxide is produced from wells drilled in the Quaternary alluvium in Ukiah and east of Hopland. A small production of chromite has come from lenses in serpentine. Extensive deposits of sub-bituminous coal occur in the Cretaceous formations east of Dos Rios in the northeastern portion of the county. Copper carbonate and some sulphides have been found in lenses of metamorphosed sedimentary rocks in several localities. Limestone beds occur in the Franciscan formation northwest of Calpella and 2 miles north of Laytonville. Manganese oxide, manganese carbonate, and manganiferous chert occur in lenses of the Franciscan formation in many localities in eastern Mendocino County. Carbonated mineral springs have been developed in the vicinity of Ukiah and Hopland. A small quantity of quicksilver was mined from altered serpentine at the Occident mine near Hopland in 1906. Platinum and gold are found about 2 miles east of Hopland and near Calpella in gravels derived from serpentine and Franciscan metamorphic rocks. Natural gas is produced from a well about 3 miles east of Willits, and some methane gas is associated with the carbon dioxide produced from wells in Ukiah and near Hopland. Bituminous shales and sandstones outcrop in the Point Arena area but no commercial production of petroleum has been made. The mines and mineral deposits of Mendocino County have been described by Averill.[64]

Significant Activities During 1947. Liquid carbon dioxide and dry ice were produced from gases pumped from wells in Ukiah and Hopland during 1947. The liquid carbon dioxide was used to refrigerate fruit and vegetables shipped from Ukiah. Dry ice was shipped from Hopland in blocks weighing 60 pounds each to customers for use as a refrigerant and as a source of carbon dioxide for carbonated beverages. A coal deposit on the north side of the Eel River about 6½ miles east of Dos Rios was prepared for operation as a strip mine in 1947. Sand and gravel were mined from bars on the Russian River east of Ukiah and from bars along the Eel River and used as a concrete aggregate and for road building. J.C.O.

MERCED COUNTY

General Geologic Features. Merced is one of the northern San Joaquin Valley counties. A central alluvial plain trending northwestward occupies about 60 percent of the county's land area of 1,995 square miles. Through the middle of this plain the San Joaquin River flows to the northwest. It is fed by the Merced River, its chief tributary, from the northeastern part of the county, and by numerous intermittent streams from both sides of the valley. The central plain is made up of unconsolidated sands, gravels, and clays of Quaternary age which extend about 15 miles southwest and about 20 miles northeast of the San Joaquin River.

A fringe of Cenozoic strata not over 2 miles wide marks the western limit of the central plain. These strata include Quaternary terrace deposits, Quaternary and upper Pliocene sediments, and upper Eocene marine sediments. The Cenozoic rocks are flanked on the west by a band of Upper Cretaceous sediments which strike N. 40° W., dip 40° NE., and range from 3 to 5 miles in width. These rocks represent only the Chico, which in this region has been subdivided into the Moreno forma-

[64] Averill, Charles V., Mendocino County: California Div. Mines Rept. 25, pp. 456-467, 1929.

tion above, and the Panoche formation below.[65] The Moreno consists of gritty yellowish sandstone grading downward into diatomaceous clay shale; the Panoche is essentially marine sandstone, and conglomerate near its base. The Franciscan formation of Mesozoic age unconformably underlies the Cretaceous rocks, extending westward from a zone of rolling hills to the summit of the Diablo Range at the western border of the county. The Franciscan formation is composed of sandstone, shale, chert, glaucophane schist, and altered basic igneous rocks. A major unconformity separates the older pre-Tertiary rocks from a series of Tertiary intrusive and extrusive rocks which cover an area of about 100 square miles in T. 11 S., R. 7 E. These igneous rocks vary from basalt at the base, through andesite, to bodies of intrusive rhyolite.

Low-rolling foothills of the Sierra Nevada arise from the central alluvial plain in the northeastern part of the county. Here continental sediments of middle and upper Miocene and upper Eocene age are exposed. They dip slightly westward under the valley alluvium and on the east they rest on the upturned edges of the Mariposa slate of Jurassic age. There is a wide variation in lithology and color in these clastic rocks. The basal beds consist of light-colored sandstone containing slate fragments and white quartz pebbles, followed by sandstone, clay, and some tuff. Overlying them is a series of sandstones and andesitic gravels with some interbedded tuff.

Mineral Resources. Metallic and nonmetallic minerals which have been produced commercially in Merced County in substantial amounts include: cement, clay, gold, sand, and gravel. Minor amounts of copper, gypsum, lead, magnesite, platinum, and silver have been produced. A sandy clay located 2 miles south of Merced has been used to make hollow tile, roofing tile, and face brick; local clays north of Merced have been used in making cement. Small amounts of copper have been produced intermittently since 1901 from an area southwest of Dos Palos. Deposits of diatomaceous earth have been reported in the west side of the county from an area south of Ortigalita Creek. Gold is found in the sands and gravels of most of the streams entering the county from the Sierra Nevada. The chief gold production has been from dredges operating along the channels of the Merced River in the vicinity of Snelling. Silver and platinum are produced as a by-product of gold dredging. Sand and gravel are produced at numerous points throughout the county.[66]

Significant Activities During 1947. The Snelling Gold Dredging Company operated unit No. 1 all year on the south side of the Merced River, and unit No. 2 was placed in operation on the north side of the river during the last quarter of the year. Unit No. 2 is a bucket-line dredge; each of its 72 buckets holds 7½ cubic feet of gravel. At its present location the dredge digs 25 feet below the water-level, but it has a maximum dredging depth of 40 feet. The gravel is minus 6-inch with occasional boulders and little sand. Bedrock is a very hard volcanic ash. The gravel is screened with a trommel, and a clean, flaky gold is recovered, by seven lateral sluices and three longitudinal sluices on each side. The lateral sluices are about 1½ by 25 feet and most of the gold is caught in the first 10-foot length. Steel

[65] Anderson, R., and Pack, R. W., Geology and oil resources of the west border of the San Joaquin Valley, north of Coalinga, California: U. S. Geol. Survey Bull. 603, 1915.

[66] Laizure, C. McK, Merced County: California Div. Mines Rept. 21, pp. 173-183, 1925.

Hungarian riffles with rubber protective surfaces to reduce wear are used. The clean-up consists of amalgam and sand which is reconcentrated in a clean-up box and a long-tom.

The River Rock Company, 435 15th Street, Merced, constructed a new steel and concrete plant on the north side of the Merced River and began producing crushed rock products in August 1946. River sand and gravel, containing no clay, is excavated by a caterpillar-mounted, 1½-yard dragline which delivers to end-dump trucks. The trucks traverse a semicircular ramp discharging their load to a grizzly at the midpoint. The crushing plant consists of a jaw crusher, a 3-foot Telesmith crusher, a fine crusher, and Bodinson screens. The rock can be washed if desired, although road rock is usually delivered unwashed. Stock piles are built up from the ground with tunnel conveyors for truck-loading and blending. The plant has a rated production of 700 yards per day and 10 men are employed on a 5-day week.

During 1947 the mineral production in Merced County consisted of gold, crude platinum metals, sand and gravel, and silver.

F.F.D.

MODOC COUNTY

General Geologic Features. The portion of Modoc County west of the Warner Ranges is within the Modoc Plateau province. It is a region of Pleistocene lake beds, plateaus, and rolling hills with an average elevation of almost 5,000 feet, but there are mountain peaks and volcanic ranges with elevations rising to 7,000 feet. The rock formations outcropping are flat-lying lava beds, chiefly basalt and andesite of Tertiary and Quaternary age.

The Warner Ranges in the eastern part of the county rise to elevations of almost 10,000 feet and trend northward across the entire county. Surprise Valley, containing a chain of lakes, extends along the eastern slope of the mountains to the Nevada state line. The mountain peaks and ranges in Modoc County are, with few exceptions, composed of Miocene andesite. Some Miocene rhyolite outcrops in the High Grade district east of New Pine Creek, and some Recent basalt outcrops along the border of Siskiyou County. The geology of Modoc County is shown on the map prepared by Smith.[67]

Mineral Resources. A small amount of copper ore, including azurite, cuprite, malachite, and some native copper, has been mined from narrow veins in andesite about 7 miles south of Fort Bidwell. Fine gold occurs in veins, seams, and vugs in silicified granular rhyolite breccia in the High Grade district and in fault breccia in basalt in the Winters district southwest of Canby. Hot mineral springs are found in many places in Modoc County, and there are several along the highway between Alturas and Canby. Optical-grade iceland spar has been mined from a ledge about 4 feet wide that strikes northward in the andesite of the Warner Range northwest of Eagleville. Pumice occurs in horizontal beds above a basalt floor on the eastern border of the glass flow which surrounds Glass Mountain. Perlite claims have been located in the volcanics east of Goose Lake. Salt has been obtained by evaporating water pumped from shallow wells on the east shore of Middle Lake east of Cedarville. Volcanic tuffs, suitable for building material, have been quarried in the vicinity of Alturas. Sand and gravel are produced from a deposit on the

[67] Smith, J. P., op. cit., 1916.

bank of the North Fork of Pit River about 2 miles east of Alturas. The mines and mineral deposits of Modoc County have been described by Averill.[68]

Significant Activities of 1947. The pumice deposits in the vicinity of Glass Mountain in western Modoc County were active during 1947. Most of the material was used for concrete aggregate in the manufacture of light-weight building blocks. A small amount of perlite was mined from an extensive deposit along the highway northeast of Davis Creek. Some high-grade gold ore was shipped from a deposit in the High Grade district east of New Pine Creek. The gold is very fine and occurs in seams and vugs in rhyolite breccia. Sand and gravel were mined from the bank of the North Fork of Pit River east of Alturas for building roads and for concrete aggregate. J.C.O.

Table 25. Mineral production from Modoc County during 1947

Product	Quantity	Value
Sand and gravel	198,513 short tons	[1]
Stone	79,180 short tons	[1]
Unapportioned (pumice, sand and gravel, and stone)		$116,170
Total value		$116,170

[1] Value included with "Unapportioned."

MONO COUNTY

General Geologic Features. Mono County, located midway along the eastern border of California, is essentially a broad table land bounded by high, roughly parallel north-trending mountain ranges. The western border of the triangular-shaped county follows the crest of the Sierra Nevada whose lofty eastern escarpment at Mono Lake produces a sharply contrasting relief in the area. The rugged character of the Sierra Nevada is matched in many respects by that of the White Mountains or northern Inyo Range [69] in the southeastern part of the county and of the Sweetwater Mountains along the northeastern border. Both are typical basin-range structures. White Mountain Peak in the former range is 14,242 feet above sea level, just short of the highest peaks of the Sierra Nevada. Draining the high mountains and table land between are the Owens River in the southern part of the county, the West Walker River and East Walker River in the northern and northeastern section, and the various streams flowing into Mono Lake in the central area. The latter is a remnant of ancient Lake Lahontan, an extensive inland sea.[70] The Owens River rises mainly in the Mammoth basin in the Sierra Nevada although the drainage from the west slope of the White Mountains joins the former. Waters of the Owens River and its tributaries as well as some streams of the Mono Lake drainage system have been utilized by the City of Los Angeles.

The Sierra Nevada in Mono County consists of the Upper Jurassic granitic batholith which has intruded a series of metamorphic rocks

[68] Averill, C. V., Modoc County: California Div. Mines Rept. 32, pp. 445-457, 1936.
[69] Anderson, G. H., Granitization, albitization, and related phenomena in the northern Inyo Range of California-Nevada: Geol. Soc. America Bull., vol. 48, pp. 1-74, 1937.
[70] Russell, I. C., Geological history of Lake Lahontan: U. S. Geol. Survey Mon. 11, 288 pp., 46 pls., 1885.

ranging from Cambrian to Jurassic in age. The Paleozoic rocks of this latter group consist of slate, hornfels, and crystallized limestone overlain by a series of schistose, slaty, and gneissic rocks of probable Triassic and Jurassic age.[71] The metamorphic rocks are overlain discordantly by a volcanic series, largely upper Miocene and in part Pliocene, Pleistocene, and perhaps Recent. These volcanics, flanking the Sierra Nevada and extending northward from the volcanic tableland north of Bishop, comprise a large area of eruptive activity. Mono Craters, south of Mono Lake, are a series of obsidian domes and coulees of late Pleistocene age.[72] The volcanic rocks are chiefly andesite with some rhyolite, basalt, and pyroclastics, including pumice. The pumice beds extending southward and southeastward from Mono Lake are of considerable economic importance.

The White Mountains are a thick series of sedimentary rocks including bedded andesitic lavas, all of which have been intruded by large masses of granite.[73] The pre-Pliocene sedimentary rocks range in age from Lower Cambrian to Triassic and include limestone, dolomite, sandstone, and shale members. The White Mountain batholith which intrudes these metasediments is related to the Sierra Nevada batholith. The entire series is faulted and greatly folded. The Benton Range, a lower range of mountains rising above the volcanic tableland between the Sierra Nevada and the White Mountains is a series of altered sedimentary rocks comprised of schist, quartzite, limestone and marble intruded by late Jurassic granite. Tertiary extrusives outcropping here include pyroclastics and basaltic flows, a part of the extensive volcanic series of Mono County.

Mineral Resources. Both metals and nonmetals are included in the mineral production of Mono County since 1880. More than three-quarters of the recorded production, 33 million dollars, has been from gold and silver. The principal lode gold and silver production has been from the Bodie and Masonic districts, located several miles north of Mono Lake. Other contributing districts have been the area west of Mono Lake, the Mammoth district, the Blind Spring Hill district and the Chidago district in the southern part of the Benton Range. A production of more than 30 million dollars in gold and silver, a considerable amount of which was produced before 1880, is credited to the quartz veins in andesite at Bodie.[74] Placer gold has been recovered from the headwaters of the Walker River, Virginia Creek, Dog Creek and Bodie Diggings north of Mono Lake. The important silver-producing areas of the county are the Blind Spring Hill district near Benton and the Patterson district in the Sweetwater Mountains. The ores of the Blind Spring Hill district are mesothermal deposits of complex lead, copper and silver occurring as fissure fillings within a granitic stock.[75] The important production of the district has been from the secondary enrichment zone. The Patterson district, located on the east slope of the Sweetwater Mountains near the state line has ores of argentite, cerargyrite, pyrite, and gold. Lead and

[71] Mayo, Evans B., Preliminary report of the geology of southwestern Mono County, California: California Div. Mines Rept. 26, pp. 475-482, 1930. . . . Geology and mineral deposits of Laurel and Convict basins, southwestern Mono County, California: California Div. Mines Rept. 30, pp. 79-90, 1934.

[72] Putnam, William C., Mono Craters: Geog. Rev., vol. 28, no. 1, pp. 68-82, 1938.

[73] Knopf, Adolph, and Kirk, Edwin, a geological reconnaissance of the Inyo Range and the eastern slope of the Southern Sierra Nevada, California: U. S. Geol. Survey Prof. Paper 110, 130 pp., map, 1918.

[74] Sampson, R. J., and Tucker, W. B., Mineral resources of Mono County, California: California Div. Mines Rept. 36, pp.117-156, 1940.

[75] Ransome, Alfred L., Geology and ore deposits of the Blind Spring Hill mining district, Mono County, California: California Div. Mines Rept. 36, pp. 159-197, 1940.

zinc occur in narrow belts of crystalline limestone in the Gull, June, and Virginia Lakes areas. These minerals are also found in the West Walker River district near Topaz, together with copper, gold, and silver. Molybdenum occurs south of Coleville and also as an associated mineral in tungsten ores of the south Benton Range area. The principal tungsten deposits are located in the southern part of the Benton Range and in the southwestern corner of the county near McGee Creek. The tungsten ore, scheelite in tactite, occurs as contact-metamorphic deposits in these districts as well as in the other tungsten areas which include the northern end of the county near Coleville, Saddlebag Lake area north of Tioga Pass and the Bloody Mountain area.

The unusual deposit of andalusite occurring in Dry Creek Canyon on the west slope of the White Mountains has been called the largest of its kind in the world.[76] Contact-metamorphic action between the granitic rocks and alumina-rich sediments is the source of the mineralization. In the same general area pyrophyllite, used principally as a carrier in insecticides, is found.

The volcanic series of Mono County contains extensive beds of pumice which have been mined in large quantities for use as light aggregate in concrete, insulating and acoustical plasters, and for abrasives. One operation produces sawed blocks of pumice for cleaning purposes. Perlite, a variety of rhyolite, is found south of Mono Lake. Vermiculite, another mineral of current interest for light aggregate purposes, has been reported to occur south of Coleville.

Other mineral resources of the county include quicksilver, barite, clay, travertine, building stone (tuff), sand and gravel. The waters of Mono Lake contain many soluble salts and have been the source of medicinal salts. Numerous mineral springs provide water supplies for popular resort areas as well as for domestic use in some sections.

Significant Activities During 1947. Metal mining activities in Mono County were limited to a few operations from which a small amount of gold, silver, lead, and copper was produced. The Sierra Mines, Inc., made preliminary plans for surface mining at Bodie but a disastrous fire which destroyed the mill halted the program. Greater activity in metal mining is anticipated as a result of the exploratory and development programs commenced or planned by several operators. During the latter part of the year, the Black Rock mine, 18 miles southwest of Benton, was concentrating about 50 tons of tungsten ore per day.

Of the industrial minerals, pumice played an important part in the county in 1947. Deposits from the southern margin of Mono Lake to the southern county line were worked to provide a variety of products. A novel pumice product in the form of block pumice for abrasive and cleaning purposes is produced by the United States Pumice Supply Company, Inc., at their modern plant in Leevining. A considerable amount of the pumice mined in the county is used as a light aggregate in concrete, both poured and block. H. S. Van Loon of Bishop uses pumice from the Yellow Jacket Springs area in the manufacture of precast pumice-concrete slabs for building purposes. Pumice for use as an abrasive is produced by the Pacific Coast Pumice Company. This company entered its twelfth year of continuous production of such abrasive material. A new finishing plant, capable of producing 14 finished grades

[76] Sampson and Tucker, op. cit., 1940.

of abrasive pumice was completed during the year. Plaster aggregate material, utilizing pumice as one ingredient, is being produced by the Insulating Aggregates Company in their new 70 tons per day plant north of Laws.

The industrial requirements for pyrophyllite, used considerably as a carrier in insecticides, has been augmented by the output from the new grinding plant of the Huntley Industrial Minerals, Inc., at Laws. The deposit is located on the northwest slope of the White Mountains.

The production of small quantities of sand, gravel, and stone, was also reported. L.A.N.

Table 26. Mineral production from Mono County during 1947

Product	Quantity	Value
Copper	18,000 pounds	$3,780
Gold	41 troy ounces	1,435
Lead	17 short tons	4,896
Pumice	4,738 short tons	220,088
Silver	7,323 troy ounces	6,627
Unapportioned (pyrophyllite, sand and gravel, stone, and tungsten concentrates)		96,067
Total value		$332,893

MONTEREY COUNTY

General Geologic Features. Monterey County, one of the coast counties, is largely a mountainous region containing the Sierra de Salinas, and parts of the Santa Lucia Range, the Gabilan Range, and the Castle Mountain Range, all parts of the Coast Ranges. All of these ranges trend northwestward, and the Salinas River, in a fertile valley averaging about 6 miles in width, has a similar trend through the center of the county. The mountains are made up of a basement complex of granite and metasedimentary schists of pre-Franciscan age, possibly Paleozoic or pre-Cambrian; extensive bodies of Franciscan (Jurassic) sediments; and a series of Cretaceous, Tertiary, and Quaternary sediments. A few lenses of marble are found in the metasedimentary complex. Tertiary and older formations have been intricately folded and faulted. The eastern boundary of the county is near the San Andreas fault, which strikes northwestward. Parallel faults are found in the center of the county and near the coast.

Between the San Andreas fault and the Nacimiento fault is a belt trending northwestward, 40 miles wide, of the basement complex of the Coast Ranges; hence the rocks of Monterey County are in large part much older than rocks generally found in the Coast Ranges. This belt is believed [77] to have been a land mass during the Franciscan, Cretaceous, Eocene, Oligocene, and possibly lower Miocene, and to have extended northwest far beyond the present coast. The Nacimiento fault strikes northwestward across the coast line at a point 40 miles southeast of Monterey, but apparently re-appears for some miles at Point Sur before disappearing again in the ocean. Here it has been called the Sur thrust by Trask.[78] The geology of a part of this belt adjacent to the San Andreas

[77] Reed, Ralph D., Geology of California, 355 pp., 60 figs., Am. Assoc. Petroleum Geologist, 1933.

[78] Trask, Parker D., Geology of Point Sur quadrangle, California: Univ. California, Dept. Geol. Sci. Bull., vol. 16, pp. 119-186, 1926.

fault, and including a part of the Gabilan Range, has been described by Allen [79] in his report on the San Juan Bautista quadrangle.

The geology of the Jamesburg quadrangle near the center of the county has recently been mapped by Fiedler.[80] The Monterey submarine canyon, off the coast of the county, has been described by Francis P. Shepard.[81] This canyon, beneath the surface of the Pacific Ocean, is comparable in size and shape to the Grand Canyon of the Colorado River.

Mineral Resources. Large resources of glass sand, ordinary sand, gravel, and miscellaneous stone exist in Monterey County, and these mineral substances are produced in considerable amounts. The glass sand, although classed as silica, contains much feldspar, which is not objectionable for container-glass. Dolomite is found in the pre-Franciscan metasediments of the Sur series in the foothills of the Gabilan Range near Natividad and is mined on a small scale as a refractory and on a large scale for the production of magnesium compounds. Part of the magnesium originates in the dolomite and part in the sea water utilized at the plant at Moss Landing. Salt is produced by solar evaporation of sea water at Moss Landing also. Production of about 1,500 flasks of quicksilver has come from the extreme southeastern part of Monterey County near Parkfield. Considerable money has been spent on developing and equipping a coal deposit at Stone Canyon, but actual production has not been large, and the mine has been idle for years. Gold has been produced on a small scale from both placer deposits and quartz veins, but the output for a year has seldom exceeded $10,000. Beds of diatomite found west of Bradley strike northwestward and may be followed for 40 miles. Production was maintained for many years from deposits near Bradley. Numerous lenses of limestone are found in the Sur series of metasediments, and a number of them were formerly utilized for beet-sugar refining. Mineral springs are utilized in connection with resorts. Shales and sandstones quarried from the Monterey formation near Carmel and utilized as decorative building-stones have been described by Galliher.[82] These stones are known by the names, "Santa Lucia stone," "Carmel Stone," "Monterey stone," and "chalk-rock." Other metals or minerals of which some production has been made in the past or of which prospects have been found include the following: antimony, arsenic, barite, chromite, clay, copper, feldspar, garnet, graphite, iron, lead, manganese, natural gas, and serpentine.

Significant Activities During 1947. One of California's war-born industries that continues to run at capacity in peace-time is production of magnesia from dolomite and sea water by Permanente Metals Corporation at Moss Landing. Although this plant originally furnished magnesia for the production of metallic magnesium, it is now operated to capacity for the manufacture of refractories. Calcined dolomite from the quarry at Natividad, Monterey County, operated by the same company, is trucked to Moss Landing and is added to sea water pumped from Monterey Bay. The reaction is controlled to produce a precipitate of nearly pure magnesium hydroxide, which is thickened, filtered, dried,

[79] Allen, John Eliot, Geology of the San Juan Bautista quadrangle, California: California Div. Mines Bull. 133, 112 pp. 1946.

[80] Fiedler, W. M., Geology of the Jamesburg quadrangle, Monterey County, California: California Div. Mines Rept. 40, pp. 177-250, map, 1944.

[81] Shepard, Francis P., Submarine canyons off the California coast: California Div. Mines Rept. 34, pp. 298-310, 1938.

[82] Galliher, E. W., Geology and physical properties of building stone from Carmel Valley, California: California Div. Mines Rept. 28, pp. 14-41, map, 1932.

Table 27. Mineral production from Monterey County during 1947

Product	Quantity	Value
Sand and gravel	646,973 short tons	$1,022,058
Stone	147,730 short tons	232,980
Unapportioned (lime, magnesium compounds, petroleum, salt, sand and sandstone [ground])		1,347,259
Total value		$2,602,297

and then calcined in a rotary kiln at 1700° to 1725° Centigrade to a highly refractory grade of periclase.

Next door to the periclase plant is a second plant manufacturing refractory brick of many different compositions—brick made entirely of periclase and a binder, brick in which chrome ore predominates over periclase, and brick in which periclase predominates over chrome ore. Many different sizes and shapes are made to fit various cement and other kilns, open-hearth furnaces, and electric furnaces. Ramming mixes for the bottoms of the furnaces and mortars are made also. Dolomite, periclase, and refractory brick are all produced in excess of the requirements of Permanente and other Kaiser companies such as the cement company and the iron and steel plant at Fontana; hence all of these products are sold on the market.

Sea water is also used as a source of salt at Moss Landing by Monterey Bay Salt Works.

Del Monte Properties Company and Owens-Illinois Glass Company produce silica sand for the glass and ceramic industries from beach dunes near Pacific Grove. The sand is washed, put over concentrating tables for the removal of heavy minerals, then dried and put through magnetic machines for the removal of iron-bearing minerals such as dark mica. Part of the sand is ground in a pebble mill for ceramics.

An oil well in sec. 27, T. 22 S., R. 10 E., M. D., near San Ardo started to produce low-gravity petroleum on a commercial scale late in 1947. This well is west of the San Andreas fault, and additional geological study is expected to indicate favorable conditions for further drilling. Apparently the county has now become a regular producer of petroleum.

C.V.A.

NAPA COUNTY

General Geologic Features. Napa County, bordering San Pablo Bay on the north, is one of the original 27 counties formed in 1850. It is characterized by mountain ranges and intermontane valleys trending northwestward which lie in the southern part of the northern Coast Ranges of California.

A belt of Lower Cretaceous rocks of the Shasta series outcrops along the entire eastern border of the county and extends westward to an average width of about 4 miles. The Shasta series has been subdivided into two groups,[83] the Horsetown above, and the Paskenta below. The Horsetown consists mainly of light-colored, thin-bedded sandy shales, and is exposed in the hills traversed by Putah Creek from Monticello eastward to the county line. These beds dip eastward about 45 degrees and have

[83] Anderson, F. M., Berryessa Valley: California Div. Mines Bull. 118, pp. 616-618, 1943.

an estimated thickness of 12,400 feet. The Paskenta is found in the foothills west of Putah Creek and has an estimated thickness of 8,600 feet. This formation contains shale with interbedded lenses of limestone overlying beds of sandy shale and hard sandstone.

The belt of Cretaceous sediments is flanked on the west by a parallel strip of light-colored sandstones and dark-colored shales which constitute the Knoxville formation of late Jurassic age. This strip is about 1½ miles wide and extends from the northern boundary of the county to the south end of Berryessa Valley. The Knoxville formation strikes about N. 35° W. with an average dip of about 80° E. Knoxville beds also outcrop in and around Pope Valley.

The Franciscan formation underlies the Knoxville and is exposed throughout that portion of the county north of township 7 north. The Franciscan is separated into a sedimentary series of hard sandstones, shales, limestone lenses, chert, and schists, which have been intruded by basic igneous rocks. The intrusives are essentially peridotite, altered to serpentine and greenstone.

The east flank of Napa Valley is composed of a thick group of Pliocene volcanic rocks extending over an area of about 120 square miles. These rocks exhibit considerable lateral and vertical variation, ranging from andesite near the base, up through andesitic conglomerate, basalt, scoria, agglomerate, breccia, vitrophyre, tuff, pumiceous tuff, obsidian, perlite, and trachyte near the top of the succession. Collectively they are known as the Sonoma group and have a total thickness of more than 4,000 feet.[84] The members of the group are generally conformable. A typical section may be seen east of Napa along Highway 37 on the west side of the Howell Range. Here, the volcanics dip westward at an angle of about 15°, forming the east limb of a regional syncline. The beds then pass under the alluvium of Napa Valley and are again exposed on its west flank where they overlie the Cretaceous sediments and dip gently eastward.

Mineral Resources. The minerals of Napa County which were produced commercially in 1947 are: mineral water, pumice, quicksilver, sandstone, and miscellaneous stone. The numerous mineral springs have made this county famous as a center of rest and recreation resorts. Pumice occurs on the east side of Napa Valley as pumiceous tuff and breccia in the thick group of Pliocene volcanics. The tuff is capped by a trachyte flow, part of which has been uplifted and removed by subsequent erosion. Present mining operations are conducted 3 to 7 miles east of Napa along Highway 37 in areas where there is no overburden. Large deposits of perlite and obsidian, also associated with the Pliocene volcanics, have been mapped east of the Silverado trail between Conn Creek and Glass Mountain. The perlite is centered around sec. 34, T. 8 N., R. 5 W., and the obsidian is centered around Glass Mountain. Perlite and obsidian have a potential value as source material for synthetic pumice, which will be used in the manufacture of lightweight building material. Quicksilver has contributed more to the value of Napa County production than any other mineral. The principal producing districts are the eastern Mayacmas and Knoxville. The deposits of quicksilver are near or along sandstone-serpentine contacts in the Franciscan rocks of Jurassic age. The contact rocks are often characteristically altered to masses of silica-

[84] Osmont, V. C., Geological section of the Coast Ranges north of the bay of San Francisco: Univ. California Dept. Geol. Sci., Bull., vol. 4, pp. 39-87, 1904.

carbonate rock. The ore deposits may consist of bodies of disseminated cinnabar, cinnabar veins, or stockworks of cinnabar veinlets. Reserves are seldom developed in advance of ore extraction. Sand and gravel is produced from Recent creek-bed deposits. The basalt members of the Pliocene volcanics furnish abundant supplies of tough, dense, paving blocks and rock for crushing. Other minerals which have been produced commercially in the county are: building stone, chrysotile asbestos, chromite, clays, copper, gold, limestone, magnesite, manganese, sandstone, and silver. Quartz veins bearing silver sulphides, associated gold, small amounts of copper, and traces of lead, were found on the lower slopes of Mount Saint Helena as early as 1870. The Silverado mine was worked intermittently until 1927. The Palisade mine was worked until 1941.[85]

Significant Activities During 1947. The discovery of a large deposit of perlite in Napa County was made late this year. Crude perlite is now commercially important as a source of "expanded perlite," a synthetic pumice. The crude material is a volcanic glass composed of tiny spheroids, and much of it contains phenocrysts of quartz or feldspar. It is acidic, contains water, and was ejected as lava flows during periods of volcanic eruptions. When crude perlite is suddenly heated the contained water expands producing a frothy material known as "expanded perlite." The expanded product is valuable as a lightweight aggregate in plasters, concrete, and building blocks. The new discovery is located 2 miles east of Rutherford railroad station, about 60 miles north of San Francisco, in secs. 32, 33, 34, and 35, T. 8 N., R. 5 W., M. D. The perlite occurs as thick flows in a group of folded Pliocene rocks known as the Sonoma volcanics. The National Perlite Company of Campbell is now mining perlite on the Holt ranch in this vicinity.

Pumice in the form of a pumiceous tuff is also found in the Sonoma volcanics on the east side of Napa Valley. All the tuff in this group is not pumiceous. Variation from tuff entirely barren of pumice fragments to tuff completely composed of pumice fragments separated only by thin shells of clay can be seen. This group of volcanic rocks has a wide lateral distribution, and is well exposed east of Napa along Highway 37 on the west slope of the Howell Range. Here the volcanics dip about 15° SW. The pumice members of the group are being mined at this locality, where an excellent road permits easy access to the deposits. At many points in this area the overlying hard cover of trachyte has been removed by erosion and the necessity of stripping is thereby eliminated.

All the present workings are open cuts. The milling operations consist of grinding to free the pumice particles, washing to eliminate the impurities, and drying to remove excess moisture. The sequence of these operations is subject to variation depending on the amount of impurities present and the demands of the individual producer's market. Most of the Napa pumice is used in the manufacture of pre-cast building blocks and as a light-weight aggregate in concrete. The principal pumice producers in this area are Basalt Rock Company and C. Cicero.

Crushed rock accounts for a major part of the total value of mineral production in Napa County. The Basalt Rock Company operates a large quarry in a basalt flow 2½ miles south of Napa. The quarry rock is loaded by crawler-mounted shovels and run through a modern three-stage elec-

[85] Davis, Fenelon F., Mines and mineral resources of Napa County: California Div. Mines Rept. 44, pp. 159-188, 1948.

trically operated crushing plant with a rated capacity of 2,500 tons per 8-hour day. Sized products ranging from minus $\frac{3}{8}$-inch to 8-ton caprock are produced. The Juarez quarry operated by M. L. Reidenback also produces crushed rock from a basalt flow. The McGill Rock and Sand Company produces crushed rock from the gravels of Conn Creek east of Oakville and a similar type of operation is conducted by H. V. Smith on Sulphur Creek west of Saint Helena.

A small quantity of quicksilver was produced from the Knoxville mine.

Mineral water was bottled at Napa Soda Springs. F.F.D.

Table 28. Mineral production from Napa County during 1947

Product	Quantity	Value
Stone	161,440 short tons	$202,386
Unapportioned (mercury, pumice, and sand and gravel)		157,525
Total value		$359,911

NEVADA COUNTY

Geologic Features. Nevada County is situated entirely within the Sierra Nevada geomorphic province and has been identified with mining from the time of its inception. The Grass Valley-Nevada City gold district has been the largest producer of lode gold in the state, and though not related structurally to the Mother Lode system, is nonetheless similar in age and is a part of the gold belt which extends through the foothills of the Sierra from Plumas to Mariposa County.

The bedrock complex of the eastern third of the county is largely buried under considerable thicknesses of late Tertiary and Pleistocene volcanics, chiefly andesite and basalt. The main stream systems have cut down into bedrock west of the backbone of the Sierra (north of Donner Pass) and fluvial erosion and glaciation have exposed bedrock along the high ridges. Where the bedrock is exposed it consists chiefly of grandodiorite with occasional roof pendants or remnants of metamorphosed sedimentary rocks lying on and intruded by granitic rock. Glacial features abound in central Nevada County where glaciers have abraded the hard bedrocks and left large quantities of glacial debris.

The bedrock of the east central part of the county consists mainly of granitic rocks together with smaller areas of metasediments and metavolcanics which the granitics intruded. The granitics are of Upper Jurassic age and the rocks they intruded are partly of Upper Jurassic and partly of Upper Paleozoic age. Erosion remnants of Miocene and Pleistocene volcanics lie on the eroded bedrock surface in many places. There are a great many lakes in this part of the Sierra, mostly of glacial origin. Some are of cirque type and others are the result of damming of watercourses by glacial debris. Pleistocene glacial deposits are very extensive, particularly between Fuller and Bowman Lakes east of the watershed of Canyon Creek.

West of Graniteville, a broad belt of tightly folded metasediments and metavolcanics begins which extends the rest of the way across the county. The general strike of this system is somewhat north of northwest. This structural trend of the bedrock is disrupted in numerous places by

instrusions of granitic rocks ranging in composition from gabbro to granodiorite. Stocks and irregular intrusions of ultrabasic rocks such as peridotite and pyroxenite of pre-granite, Jurassic age also invade the folded series.The greater part of the exposures of folded rocks is either metavolcanic greenstones of uncertain age or slates, cherts, phyllites, schists, and crystalline limestones belonging to the Calaveras formation which is Carboniferous in age.

Gold lodes are numerous in the vicinity of Grass Valley and Nevada City and, to a lesser extent, as far east as Graniteville. These cut the Bedrock series only and, conversely, placers and buried placers are confined to rocks of the Superjacent or overlying series which rests unconformably upon the bedrock. Gold-quartz veins are also scattered through other parts of Nevada County. The best available evidence indicates that the gold veins or lodes resulted from compressive shearing of the bedrock, which formed joint systems and overthrust rifts, along which rising hydrothermal gold-bearing solutions deposited their mineral materials. Overthrusting is the dominant type of faulting in the gold belt, particularly along the Mother Lode. In the Grass Valley mining district the structure is roughly dome shaped with granodiorite at the center and Calaveras metasediments at the flanks. Faults cut both the metasediments and the granitics.

Very little has been written on the general geology of areas including Nevada County since the turn of the century. Geologic folios of the U. S. Geological Survey by Lindgren, Turner, and others are still the best sources of information on the geology of the northern and central Sierra Nevada. Johnston [86] has written the latest and most complete account of the Grass Valley area. His paper includes a geologic map and bibliography.

Mineral Resources. Nevada County was, for many years, the leading producer of gold in California; but since the beginning of World War II it has fallen below one or more of the gold dredging counties in total gold output. Wartime limitations on gold mining together with high operating costs have resulted in the closing of most of the mines of the county, both large and small. Huge reserves of lode gold ore and placer gravel suitable for hydraulicking remain in the county, which some day will be exploited. The placer gravels contain enormous tonnages of accessible stone piles suitable for use as aggregate. Considerable quantities of light-colored clays occur with auriferous gravels which undoubtedly will be utilized at a future date. Red lateritic clays suitable for brick-making exist in many places in the western half of the county and have been utilized for that purpose in the past.

Small deposits of chromite, serpentine asbestos, copper, and garnet occur in Nevada County, some of which have been exploited in a small way from time to time. Copper is still produced to some extent as a by-product of gold-mining operations. The Spenceville copper mine produced considerable copper in the seventies and eighties. A fair-sized deposit of barite occurs on the property of the Spanish gold mine near Washington and several smaller deposits are known to occur in Nevada County. These are idle at present.

Mining Activities During 1947. Mineral production of Nevada County during 1947 consisted of gold, silver, and stone. Gold mining

[86] Johnston, W. D., Jr., The gold quartz veins of Grass Valley, California: U. S. Geol. Survey, Prof. Paper 194, 101 pp., 1940.

for the year was largely in connection with the Idaho-Maryland, Empire Star group, Spring Hill, Ancho Erie, Relief Hill, Omega, Gaston, and Waukesha mines. The Idaho-Maryland mine at Grass Valley was by far the largest operation in the county for 1947. The Empire Star group also at Grass Valley operated on a reduced scale largely through lessees. Ordinarily it is an exceedingly large operation, having produced more gold than any other mine in the state. The Spring Hill mine, located near the Idaho-Maryland, produced on a limited scale under the management of Mr. C. C. Cushwa. The Relief Hill, Omega, and Waukesha hydraulic mines, all in the north central part of the county, operated during the wet season, the former two having washed very large tonnages of gravel. The Ancho Erie mine near Washington is the most active of the smaller lode mines, having increased its mill capacity by 125-130 tons per day and having embarked on an extensive development program. The Gaston mine which adjoins the Ancho Erie to the northeast operated on a small scale during the last half of the year and is slowly increasing its daily tonnage output. A number of temporary placer and lode operations added slightly to the county production totals but very many gold mines did not operate at all.

Small tonnages of gravel and rock for aggregate and road metal were mined at several points for local use. No large aggregate plants are operating in Nevada County at present. O.E.B.

ORANGE COUNTY

General Geologic Features. Orange County, the only county which lies wholly within the Peninsular Ranges geomorphic province of California, is about 60 percent valley land, the balance being mountainous and hilly. The Santa Ana plain or valley, separated arbitrarily from the Los Angeles Basin by the San Gabriel River, is bordered on the north and northeast by the Puente Hills and on the east by the Santa Ana Mountains, a prominent range which reaches an elevation of 5,480 feet above sea level on Santiago Peak. The San Joaquin Hills, of relatively low relief, parallel the southeastern border of the county along the Pacific Ocean. The Santa Ana River with its tributaries, the most important of which is Santiago Creek, drains the larger portion of the western, northern, and northeastern areas. The Santa Ana River marks the northern terminus of the Santa Ana Mountains, which extend 40 miles southeastward to the Santa Margarita River in San Diego County. The Santa Ana River flows westward and southwestward across the valley in a shallow trench to be joined near Santa Ana by Santiago Creek; it discharges into the ocean west of Newport Beach. Formerly it flowed into the ocean through Newport Bay. The eastern mountainous region south of the Santiago Creek watershed is drained by Aliso Creek, flowing southwestward into the ocean near Three Arches, and by Trabuco, Mission Viejo and San Juan Creeks, which join near the sea at Doheny Park.

The Santa Ana plain as a part of the Los Angeles Basin assumed its present form in late Quaternary time as indicated by the steeply tilted lower Pleistocene strata in the surrounding hills.[87] Previous to this time it was a basin in which many thousands of feet of sediments were deposited, including the Miocene and Pliocene oil and gas producing beds. The

[87] Wissler, Stanley G., Stratigraphic relations of the producing zones of the Los Angeles Basin oil fields: California Div. Mines Bull. 118, pp. 209-234, 1943.

Franciscan (Jurassic), although not encountered in drilling, is presumed to underlie some of the western section. East of the coastal plain, hills of Tertiary and Cretaceous deposits extend for several miles. These continue to the Santa Ana Mountains, the western flank of which is composed of the southwestward-dipping Paleocene, Eocene and Miocene shales, sandstones, and conglomerates which overlie, unconformably, the Cretaceous series. The Cretaceous sandstone, shale, and conglomerate in turn overlie, with pronounced unconformity, the Triassic metasediments and Jurassic intrusives and volcanics which make up the steep and rugged parts of the mountain range. The Santiago Peak volcanics, mainly andesite with some rhyolite and basalt, are the most resistant to erosion and consequently form the high peaks and ridges, such as Santiago Peak. The intrusive granitic rocks are related to the batholith of the Peninsular Ranges to the south.[88] The San Joaquin Hills located westerly across the plain from the mountains are composed of folded Tertiary and Pleistocene sediments. The Puente Hills on the northern border of the county consist of a considerable thickness of unmetamorphosed marine sedimentary beds ranging from Cretaceous to Quaternary in age.

Mineral Resources. More than 90 percent of Orange County's one billion dollar recorded mineral production since 1889 has been from the prolific oil and gas formations in the Tertiary marine sediments in the southwestern and northern parts of the county. Next in importance has been the output of crushed stone, sand and gravel derived from numerous old and recent stream deposits, followed by clay and clay products. Other minerals produced have been coal, silica and glass sand, salt, mineral waters, gold, silver, lead, zinc, copper, and quicksilver.

The oil producing localities of the county include the southwestern fields of Newport, West Newport, Huntington Beach and the easterly extension of the Seal Beach field. In the northern part of the county are the East and West Coyote Hills, La Habra, Brea, Olinda, Yorba, Richfield, and Kramer fields. The Newport field has been one of the few in the Los Angeles Basin to prove commercially unsuccessful. The Huntington Beach field on the other hand has been the third largest producer in the Los Angeles Basin. Of particular interest and value at Huntington Beach are the offshore oil pools producing from wells whip-stocked from the shore.

Clay deposits in Orange County are associated with Paleocene beds along the northwest slope of the Santa Ana Mountains. The Goat Ranch or Claymont deposit 7 miles west of Corona and just south of the Santa Ana River consists of 4 to 7 feet of excellent fire-clay intercalated with lignitic shales in the Martinez formation (Paleocene).[89] It is used in making high-refractory fire-brick. Another productive clay area is located in the Trabuco-Silverado Creek section 10 to 15 miles northeast of El Toro. Several pits have produced from the Serrano clay bed in the Martinez formation. The mine-run product, part of which is iron stained and gray in color, is suitable for face-brick, low-grade fire-brick mixtures, and foundry use. The processed or washed clay, however, can be used for china clays and slip clays. Excellent high-grade ceramic

[88] Larsen, Esper S., Batholith and associated rocks of Corona, Elsinore, and San Luis Rey quadrangle, southern California: Geol. Soc. America Mem. 29, 1948.

[89] Sutherland, J. Clark, Geological investigation of the clays of Riverside and Orange Counties, southern California: California Div. Mines. Rept. 31, pp. 51-87, 1935.

Table 29. Mineral production from Orange County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[1]
Clay, raw	20,437 short tons	$72,520
Natural gas	29,399,000 M cu. ft.	2,465,000
Natural gasoline and allied products:		
Natural gasoline	115,423,000 gallons	5,911,000
Liquified petroleum gases	4,528,000 gallons	150,000
Petroleum	34,146,000 barrels	58,274,000
Sand and gravel	961,207 short tons	812,831
Unapportioned (peat, salt, and stone)		169,480
Total value		$67,854,831

[1] U. S. Bureau of the Census not at liberty to publish figure. Value not included in county total.

silica sand accompanies the clay. Associated with the clay deposits of the Paleocene in the northeastern part of the county are low-grade coal seams which were mined for many years during the early history of the county.

Lead, zinc, silver, and copper are found in a mineralized zone on the west slope of the Santa Ana Mountains. This 2-mile-wide belt extends for a distance of about 10 miles from Santiago Creek north to Silverado Canyon. The ore is found in the argillites and quartzites of the Bedford Canyon formation (Triassic), the andesites of the Santiago Peak volcanics (Jurrassic), and in small intrusive bodies. Although the mineralization is extensive and there has been a considerable amount of prospecting and some mining done in the region, the production has not been large. Southeast of this section at a point 6 miles west of Elsinore is located the Old Dominion mine, a complex ore deposit principally of lead, zinc, and silver, but containing several other metals. The mineralization occurs in a shear zone of the intensely metamorphosed Bedford Canyon formation. Farther south and southwest in Trabuco Canyon area are auriferous quartz veins; in Lucas Canyon there are gold-bearing gravels.

Quicksilver occurs in the Tertiary sandstone in Red Hill, east of Tustin. Gypsum is associated with the sedimentary series of the northwest slope of the Santa Ana Mountains.

Significant Activities During 1947. Increased production of petroleum in Orange County was the result of intensified development of known reserves and peak production in the West Newport field.

The demands of the construction industry resulted in a continued high output of sand, gravel, and crushed rock. Several plants throughout the county were engaged in the production of aggregate. Gladding McBean and Company were steady producers of refractory clay from the Claymont deposit a few miles west of Corona. Clay for foundry use and refractories was mined from several pits in the Trabuco Canyon area.

The Irvine Company reported the largest production of salt to date at their solar evaporation plant at the head of Newport Bay. Shells, dredged from the upper part of Newport Bay, are processed for use in the poultry trade by Shellmakers, Inc.

There was no recorded production of metals from the county during the year. One plant in Santa Ana processes scrap lead and lead ore from the Death Valley area for use in batteries.

L.A.N.

PLACER COUNTY

Geologic Features. Placer County is a long strip of land extending from the vicinity of Lincoln, in the Great Valley, northeastward to the Nevada border at Lake Tahoe. Hence the land surface is diverse, ranging from level valley floor to sub-alpine topography. The upper Sierra in Placer County has a wealth of glacial features which are a carry-over from Pleistocene time.

Rocks of the eastern third of the county are mainly Miocene and Pliocene pyroclastic and flow lavas, chiefly of andesitic or basaltic composition. The mid-Tertiary Sierran eruptions were exceedingly widespread and buried virtually all of the northern and central parts of the range under many hundreds of feet of volcanic material. Erosion by the main river systems has cut through to bedrock in numerous places and exposed the Eocene river-channel gravels which underlie the volcanics at many points. Beneath the volcanics and gravels, the bedrock is composed of strongly folded metasedimentary rocks and granitics intrusive into them. The metasediments in the eastern part of the county consist of schist, quartzite, crystalline limestone, and slate of undifferentiated Juratrias age belonging mainly to the Sailor Canyon formation. Glacial moraines are widespread in the upland valleys; glacially polished and grooved bedrock mounds termed roches moutonnées and huge stray glacial boulders called erratics are common; other evidences of glaciation can be seen near the backbone of the Sierra Nevada.

Central Placer County is an area from which a good deal of the volcanic Tertiary covering has been stripped. As a result, the rock exposures are predominantly of the "Bedrock" series with volcanic remnants lying unconformably on them. The Calaveras formation of Upper Paleozoic age is the dominant sedimentary group in this part of the county. Lindgren [90] has subdivided the formation into five lithologic subdivisions, the Clipper Gap, Delhi, Cape Horn, Relief, and Blue Canyon units. In addition, there are sizeable areas of metavolcanics of probable Calaveras age termed amphibolite or amphibolite schist by Lindgren. Ultrabasic intrusive rocks such as the hydrated peridotite, serpentine, of Jurassic age intrude the Bedrock series in both the west and west-central parts of the county. Many lenses of chrome ore are found in the serpentine masses.

The western part of Placer County is about equally divided between the Central Valley and the Sierran foothills. The latter are made up either of granodiorite or metavolcanic greenstones which the granitic rock has intruded. Rather extensive areas of Tertiary andesite occur in the foothills east of Lincoln but these have not the areal continuity of those of eastern Placer County. Deposits of auriferous gravel are found beneath the lava cappings or near their basal contacts with the bedrock; these are distributed along old river channels which had been cut into bedrock before the outpourings of lava took place.

[90] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas Truckee folio (No. 39), 1897

Table 30. Mineral production from Placer County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[1]
Gold	5,358 troy ounces	$187,530
Silver	807 troy ounces	730
Stone	100,410 short tons	81,976
Unapportioned (asbestos, raw clay, sand and gravel, and slate)		217,515
Total value		$487,751

[1] U. S. Bureau of the Census not at liberty to publish figure. Value not included in county total.

Mineral Resources. Clay is the most important single mineral product of Placer County at the present time. Clay production at Lincoln has increased more than 20 percent since 1946 and much greater production is anticipated for 1948. Enormous tonnages of raw clay and processed clay products are marketed at Lincoln annually.

A second nonmetallic product of which there are considerable reserves is limestone. It has been mined for use in plaster, portland cement, and sugar refining intermittently for many years, but there is no activity in the limestone industry at present.

Gold mining in Placer County in 1947 continued the upswing from the wartime low of 1943. Production was, for the most part, from placer mines. Very large resources in auriferous gravel and lode gold remain to be exploited. High operating costs have kept most of the underground gold mines inoperative; small producers mining ore running $25.00 per ton are finding it difficult to operate.

The large tonnages of gravel and stone in the auriferous river deposits of the county have not been utilized for crushed-rock products to any considerable extent so far. Most of the crushed rock marketed in the county for aggregate and road metal has been shipped in from other counties. Slate and granite for various purposes has been marketed at different times as the demand required. Slate for roofing granules is being produced in the Placerville district in increasing quantities.

Tremolite asbestos has been mined in a small way in Placer County for a number of years. It is used principally as a filter in the processing of acids, the fibers being too brittle for use in fabrics.

Mining Activities During 1947. Gladding McBean's great plant for mining and processing clay products at Lincoln is, at present, the backbone of the mineral industry in Placer County. Production of clay there was 20 percent above that of 1946, and expansion is expected to continue. Both raw clay and manufactured clay products such as sewer pipe and refractory specialties are shipped from the Lincoln plant.

Lincoln Clay Products Company adjoining Gladding McBean's property at Lincoln produces raw clay for direct shipment and does not process the clay except to crush the mined product. Clay is loaded from storage bins to railroad cars by conveyor belts.

The largest gold producer in the county for 1947 was the Horseshoe Bar dragline dredge near Forest Hill. Close to a million tons of gravel were washed there during the year. Another operation which added materially to the county gold total was the Doty Ravine placer operated

by Schwartz and Mitchell of Lincoln. The only sustained gold production from a lode mine was from the Mary Len mine between Penryn and Newcastle. Small daily tonnages of ore running slightly in excess of $25.00 to the ton were milled, and the concentrate was shipped for smelting. Small, intermittent production was reported from other placer and lode mines at Forest Hill, Ophir, Lake Tahoe, Bear River, Dutch Flat, Grouse Creek, Strawberry, Last Chance district, and Michigan Bluff.

The Noonday asbestos mine at Forest Hill produced a few tons of tremolite asbestos during 1947. This property is one of the few mines which are producing asbestos in California.

O.E.B.

PLUMAS COUNTY

General Geologic Features. The region that is now known as Plumas County was covered by the sea in the Paleozoic and early Mesozoic eras.[91] The shore-line followed roughly the eastern boundary of the State of Nevada, and most of California was beneath the sea receiving sedimentary deposits thousands of feet thick. Some oscillations of sea and land took place, and some folding, but the northern Sierra Nevada, including Plumas County, was beneath the sea most of the time from early Silurian to early Jurassic. Toward the close of the Mesozoic era the sediments were compressed in heavy folds, and intrusions of ultrabasic to acidic rocks followed. These rocks, as seen today, look like granites for the most part, but ultrabasic rocks altered to serpentine are common also. After the intrusion, the fissures and joints of granitic rocks and altered sediments became filled with veins and seams of gold-bearing quartz. A long period of erosion in the early Cretaceous planed down the mountains. Concentration of the gold from the veins began in the streams. Pauses in the erosion, when the topography had been reduced to gentle outlines in the Eocene permitted deep rock decay and promoted the liberation of gold from its matrix. Renewed uplift quickened erosion and facilitated the further concentration of gold throughout Tertiary time. Fluctuations of the western shore-line at times extended the streams far into areas now occupied by the Sacramento and San Joaquin valleys, or caused these water courses to debouch upon flood plains reaching high up on the flanks of the range. Faulting movements, with downthrow on the east side, had transformed an approximately symmetrical range to a monoclinal one with steep easterly slope. Gradually the mountains were eroded to gentler slopes and the canyons widened to valleys. Meandering among longitudinal ridges, the rivers flowed from low divides to rolling foothills, and the whole slope was clothed in the dense vegetation of a damp semi-tropical climate. At this time the region was one of low relief, with one river (Jura River) flowing northward into an arm of the sea near the present site of Susanville. Other rivers flowed westward and southwestward.

Volcanic forces asserted themselves toward the end of Tertiary time. Rhyolite flows filled the valleys, covered the auriferous gravel, and new stream courses were established in the old valleys. Uplift of the Sierra Nevada became strongly emphasized, and the streams began to cut their beds deeper; they repeatedly crossed their old courses, and the concentration of gold in the new canyons proceeded. Eruptions of andesitic

[91] Lindgren, Waldemar, The Tertiary gravels of the Sierra Nevada of California: U. S. Geol. Survey Prof. Paper 73, 226 pp., 1911.

tuffs then buried a large number of streams, filling their valleys to the rim. Increased relief of the Sierra magnified the erosive power of the new streams, and thus began the canyon-cutting epoch of the late Pliocene and early Quaternary. The new streams excavated sharp, V-shaped trenches in the hard rock to depths of 1,000 to 4,000 feet below the surface of the flows. In many places the old rivers of the Tertiary period were exposed, and cross-sections of their valleys are now seen on the steep canyon slopes high above the present river beds. Large stretches of the old channels remained secure below their blanket of 1,000 feet of hardened volcanic mud. Wherever the canyon-cutting streams destroyed the old channels the gold in those channels became concentrated in the canyons, and thousands of quartz veins added to the previous concentrates; but owing to the steep grades of the Quaternary rivers much of the detrital material and the fine gold was swept out into the valley at the western foot of the range over alternately advancing and retreating flood plains.

Sierra County adjoins Plumas, which is to the north, and the geology is similar; hence the descriptions of the two counties supplement each other.[92]

Table 31. Mineral production from Plumas County during 1947

Product	Quantity	Value
Copper	28,000 pounds	$5,880
Gold	546 troy ounces	19,110
Silver	570 troy ounces	516
Stone	201,480 short tons	[1]
Unapportioned (barite, sand and gravel, and stone)		235,594
Total value		$261,100

[1] Value included with "Unapportioned."

Mineral Resources. Plumas County contains many gold deposits, both placer and lode. For several years before the war, production amounted to more than $1,250,000 per year in gold, but the county was hard-hit by the restriction of the War Production Board on gold mining during the war, and the industry has not yet revived to any great extent. The county has been an important producer of copper, and during the 10-year period from 1920-30, production of this metal averaged about $3,000,000 per year. The best year was 1929, when the value of copper production amounted to $4,444,000. Nearly all of this copper came from two mines, the Engels and the Walker. Both of these mines have been shut down most of the time for a number of years, and production of copper is now very small. During the war, considerable chrome and manganese were produced in Plumas County. Large limestone deposits exist here, and some lime and limestone has been produced, but the county is distant from large markets. Barite has been mined in quantity by means of open-pit and underground workings.

Significant Activities During 1947. Barite production continued until November 1947, and prospecting for this mineral indicates the possibility of development of further resources. Development of drift

[92] See also Averill, C. V., Mineral resources of Plumas County: California Div. Mines Rept. 33, pp. 79-143, 1937 . . . Mines and mineral resources of Sierra County: California Div. Mines Rept. 38, pp. 7-69, 1942.

mines on both sides of the Plumas-Sierra county line near La Porte was continued. A crew of 12 men was employed at one mine, and about six men at each of several others. The principal mineral production of the county recently has been miscellaneous stone, crushed rock, sand and gravel. C.V.A.

RIVERSIDE COUNTY

General Geologic Features. Riverside County, containing 7,240 square miles, is in the southern part of the state. Its boundaries encompass a strip of territory approximately 40 miles wide, extending westward from the Colorado River to the Pacific slope, a distance of about 180 miles. Some 70 percent of this area is within the Mojave Desert, about 5 percent is in the citrus belt of southern California, the remainder is in the Perris, San Jacinto, and Temecula Valleys which are separated from the desert by the San Jacinto, Coahuila, and Santa Rosa Mountains. The Pacific slope area of the county is drained by the Santa Ana River. Waters from the Perris and San Jacinto Valleys are carried by the San Jacinto River into Lake Elsinore. The Temecula Valley is drained by the Temecula River which empties into the Pacific Ocean above Oceanside. Drainage of the eastern portion of the desert area is into the Colorado River; that of the central portion goes to the Salton Sea.

The western portion of the county is in the Peninsular Ranges geomorphic province, the eastern portion in the Mojave Desert province and a north-south central strip is within the Colorado Desert province. The Peninsular Ranges trend northwestward and are separated by comparatively long valleys. The predominant rock here is granitic that has intruded the older metamorphics. The more important ranges of the Mojave Desert have a northwest trend. Some less prominent ones have an eastward trend, in this area notably the Eagle Mountains and the Palen Mountains. The pre-Cambrian and pre-Cretaceous metamorphics, here so abundantly exposed, have been intruded by Jurassic acid granitic rocks.

The Colorado Desert is described[93] as a "depressed block between active branches of the alluvium-covered San Andreas fault zone * * *."

"* * * The whole area is a structural fault trough and contains a basin of sediments surrounded and underlain by igneous and metamorphic rocks."

Mineral Resources. The mineral resources of the county include structural and industrial minerals, metals, and salines. Some 27 mineral substances have been produced commercially in the county. These are antimony, asbestos, clay, coal, copper, feldspar, gems, gold, granite, gypsum, iron, lead, limestone, manganese, magnesite, marble, mineral paint, mineral water, potash, salt, silica, silver, soapstone, vermiculite mica, tin, and zinc. Of these clay, gypsum, iron, and cement manufactured from limestone are by far the most important.

The Alberhill and Corona clay deposits constitute one of the three principal sources of clay in the state. More than 30 different types of clay have been produced here. These deposits have supplied for nearly 50 years the demands of manufacturers in the Los Angeles district.

Although gold is somewhat widely distributed in the county, its recorded production 1891-1947 has totaled only $2,616,343. The principal

[93] Jenkins, Olaf P., Geomorphic provinces of California: California Div. Mines Bull. 118, pp. 83-88, 1943.

production has come from the Pinacate, Piñon, Pinto Basin, and Dale mining districts, with minor amounts from the Chuckawalla and Riverside Mountains. The Pinacate district lies to the west and south of Perris; the Piñon, Pinto Basin, and Dale districts are in the north-central portion of the county, south and east of Twenty-Nine Palms. In each of these districts, generally, the quartz veins occur in acid granitic rocks. This is also true of the veins in the Chuckawalla Mountains; in the Riverside Mountains they are usually in schist or on a limestone-schist contact. Gold production since 1942 has been negligible.

Deposits of gypsum interbedded with limestone and schist occur in the northeastern portion of the county in the Maria and Little Maria Mountains. Here, at Midland, the United States Gypsum Company has for more than 25 years mined these deposits.

The iron ore deposits of the Eagle Mountains, in the central portion of the county, are the most important deposits known to exist in the state. These deposits are believed to have resulted from the action of an intrusive quartz monzonite magma on calcareous beds.[94] Investigation by the United States Bureau of Mines in 1941-42 indicated that they contain more than 40 million tons of ore. The deposits are now owned by the Kaiser Company, Inc., and supply the ore for the blast furnace at the company's steel plant in Fontana. For many years the Riverside Cement Company has manufactured cement from a limestone deposit at Crestmore, some 4 miles northwest of Riverside.

Table 32. Mineral production from Riverside County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[2]
Clay, raw	283,177 short tons	[1]
Gold	30 troy ounces	$1,050
Iron ore	27,029 long tons	[1]
Sand and gravel	472,839 short tons	517,871
Silver	15 troy ounces	14
Stone	138,250 short tons	156,700
Unapportioned (cement, raw clay, crude gypsum, and iron ore)		7,705,580
Total value		$8,381,215

[1] Value included with "Unapportioned."
[2] U. S. Bureau of the Census not at liberty to publish figure. Value not included in county total.

Significant Activities During 1947. By far the most important new activity in the county in 1947 was the development work on the Eagle Mountains iron deposits by the Kaiser Company, Inc. This program included the construction of 51 miles of standard-gauge railroad from Ferrum, a station on the Southern Pacific Railroad, 3 miles southeast of Salton, to the deposits. Transportation over this road was expected to begin in the summer of 1948. Power for the haul is to be supplied by a 150-ton Baldwin diesel-electric locomotive. Approximately 2,500 tons per day will be shipped to the blast furnace at the company's steel plant in Fontana.

[94] Hadley, J. B., Iron ore deposits in the eastern part of the Eagle Mountains, Riverside County, California: California Div. Mines Bull. 129, pp. 3-16, 1948.

The United States Gypsum Company continued production from its deposit and plant at Midland. Products of the plant, the capacity of which has been increased to 800 tons per day, include wall plaster, finishing and casing plaster, wallboard, and lath. The Riverside Cement Company plant at Crestmore was in continuous operation throughout 1947. The capacity of this plant is 10,000 barrels per day. The underground mine, developed in the late twenties to extract the limestone below the level of the quarry floor, was, perforce, idle during most of the war years owing to the shortage of labor. This resulted in the opening of two new quarries in the vicinity of the plant.

R.J.S.

SACRAMENTO COUNTY

General Geologic Features. Sacramento County extends along the southern end of Sacramento Valley. The Sacramento River forms the western boundary from upper Suisun Bay to a point about 15 miles north of the capital city. The long narrow strip of delta land in the southwestern end of the county is one of the most highly productive farming areas in the world. The western part of Sacramento is only 30 feet above sea-level and the city and nearby land are protected by levees and by-passes. The American River flows westward into the Sacramento on the north side of the city. Much valuable farm land on the north side of the American River that was formerly subject to overflow has been reclaimed by a gold dredging company. From Sacramento eastward, the land rises gradually into the lower foothills of the Sierra Nevada, reaching 500 to 700 feet above sea-level at the eastern county line 21 miles east of the city.

Most of the county is covered to unknown depths by Quaternary deposits of sand, gravel, and other alluvium brought into the valley by the Sacramento, Feather, and American Rivers from erosion of the Sierra Nevada. Because of the thickness of this alluvial mantle, not much is known definitely about the subsurface geology in the northern part of the county. Three small exposures of Cretaceous rock have been found in the northeast part near Folsom and one larger area on Rock Creek. In the Rio Vista gas field however, where drilling has reached a depth of more than 7,000 feet, Pleistocene nonmarine beds were found to extend to 1,830 feet below 100 feet of Recent sandy alluvium. They are underlain by upper, middle, and lower Eocene marine beds and Upper Cretaceous shale, according to R. G. Frame.[95]

The geology of the northern part of the county was described by Becker and Lindgren.[96] Exposures of Ione (upper middle Eocene) beds extend in a northwestward direction across the eastern part of the county from Amador into Placer County, from 2 to 4 miles west of the county line. In the Rio Vista gas field in the southwest end of the county, the top of the Ione is 3,000 feet or more below sea-level, and the beds are several hundred feet thick.

For several miles south of Folsom, the Ione formation was covered by Quaternary deposits of auriferous gravels. These are in part older terrace deposits of the American River, from 20 to 70 feet deep

[95] Frame, R. G., Rio Vista gas field: California Div. Oil and Gas, Summary of Operations, California Oil Fields, vol. 30, no. 1, 1944.

[96] Becker, George F., and Lindgren, W., U. S. Geol. Survey Geol. Atlas, Sacramento folio (no. 5), 1892.

and covered by clayey soil and hardpan. Old terrace gravels as well as modern stream gravels have been extensively dredged along the American River, as have similar gravels in the present Cosumnes River drainage in the extreme eastern part of the county. To the east of the Ione beds and partially covered by them, are outcrops of meta-andesite, succeeded on the east by Mariposa (Jurassic) black clay slate interbedded with amphibolite schist, both dipping almost vertically east and striking northwest. Granodiorite outcrops in the extreme northeastern corner of the county.

Mineral Resources. Hydraulic mining of auriferous gravels along the Ione shoreline in the Michigan Bar district, and drift and hydraulic mining for gold near Folsom, followed the first placer mining in the modern streams. For nearly 50 years, however, the importance of Sacramento County as a gold producer has depended on the operation of bucket dredgers. Since gold-dredging started on the American River near Folsom in 1899, Sacramento County has produced more than $95,000,000 worth of the yellow metal, mostly from bucket dredgers, but with substantial amounts coming from dragline outfits since 1933. The site of dredging operations has moved from the present American River southward into the older terrace deposits. Metals of the platinum group as well as considerable silver, have been produced as by-products of gold dredging.

Dry natural gas was produced in small quantities from wells in Sacramento for many years prior to the discovery of the Rio Vista gas field, in June 1936,[97] located 30 miles southwest of Sacramento. The discovery well was 2 miles west of Rio Vista, Solano County, but before long, the productive area was extended to the vicinity of Isleton, Sacramento County, and southeastward into Contra Costa County. This is the largest gas field in the state, with a proved area of 21,750 acres as of early 1947. Of this, 13,000 acres is in Sacramento County, mostly south and east of Sacramento River. The land surface is a delta region traversed by sloughs. The Sacramento River forms the county line with Solano County, and divides the field. The Emigh gas zone, first struck at 3,775 feet in depth, was the sole source of production for 7 years, but deeper gas zones have since been found. In the Emigh zone, two gas sands of middle Eocene age were productive. The Ione white sand is 200 to 315 feet thick and the Domengine green sand is from 70 to 150 feet thick. The deeper wells are reported to extend through older Eocene formations. The Midland fault zone strikes west of north through the Sacramento County part of the field and deeper gas zones were found on both sides of the fault, the deepest at 5,820 feet. In point of gas reserves and annual production, the Rio Vista gas field has been the largest in the state for several years. The estimated gas reserve as of June 30, 1947 [98] was 3,732,497,155 Mcf. Withdrawals have been at the rate of 130,000,000 to 150,000,000 Mcf. a year recently.

Large quantities of sand, gravel, and crushed rock are produced and marketed in Sacramento County from deposits along the American River, from dredger tailings and from older terrace deposits near Perkins, just east of Sacramento. This business ranks third in total value of annual production.

Ione clays of several grades are produced from deposits near Michigan Bar in the eastern foothill region.

[97] Frame, R. G., op. cit.
[98] California Div. Oil and Gas, Summary of Operations, vol. 33, no. 1.

Significant Activities During 1947. In value of natural gas produced, Sacramento County led the state in 1945, 1946, and 1947. In volume of production, Sacramento County was third; Los Angeles and Kern Counties were first and second respectively. Most of the Sacramento County production was from the Rio Vista field where the gas has a calorific value of 1040 British thermal units. It contains nearly 95 percent methane, less than 3 percent ethane, less than 1 percent propane and isobutane, and 1½ nitrogen. It is mixed with smaller quantities of gas from other fields (including the Thornton area, the larger part of which is in this county) and the resulting mixture sold to consumers has a British thermal unit value of 1010 to 1015.

The principal producers in Sacramento County were Standard Oil Company of California, 27 wells; Amerada Petroleum Corporation, 18 wells; and The Texas Company, 14 wells at the beginning of the year. Superior Oil Company, Natural Gas Corporation of California, Jergins Oil Company and Peter Cook Jr. had from two to five wells each.

High wages are of less importance to dredge operators than to other mining operators, as most of the work of gold dredging is done by machines. It is only natural therefore that dredging has almost fully recovered its pre-war standing and that Sacramento County was the leading gold producer in 1947 as in 1946.

The largest producer is Natomas Company with seven bucket dredgers in operation. Capital Dredging Company and Lancha Plana Dredging Company also operated one dredger each, and General Dredging Company worked with a dragline outfit. Several of the sand and gravel plants have facilities for saving gold. The production of Natomas Company alone was 81,656 fine ounces of gold in 1947, nearly 20 percent of the entire state output. This was an increase of over 10,000 fine ounces over 1947. The total gold production of the county in 1947 was 113,560 fine ounces, valued at $3,974,600.

The sand, gravel, and crushed rock business is carried on along American River in the vicinity of Fair Oaks, and in older deposits near Perkins and Brighton. The total annual value of production is from 1¼ to 1½ million dollars. Demand held up well in 1947. The larger plants are those of the Pacific Coast Aggregates, Inc., at Fair Oaks bridge; Perkins Gravel Company and Brighton Sand & Gravel Company on the Jackson road just east of Perkins; and McGillivray Construction Company's plant on 14th Avenue near 65th Street.

The clay industry is represented by four manufacturing firms in Sacramento and its suburbs. Cannon & Company produces Ione clay of several grades from deposits in the eastern part of the county near Michigan Bar and operates a plant in North Sacramento where face brick, roofing tile, patio tile and other products are made. Some clay is also sold to other users. Sacramento Brick Company makes common brick from a deposit near Sacramento River 5 miles below Sacramento. Panama Pottery Company produces no clay but uses two small kilns to make garden pottery from clay purchased. H. C. Muddox Company operates five periodic down-draft kilns to make sewer pipe, drain tile, and terra cotta at 30th and L Streets in Sacramento. All clay used at this plant is purchased. C.A.L.

Table 33. Mineral production from Sacramento County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[1]$340,000
Clay, raw	30,619 short tons	[2]
Gold	113,560 troy ounces	3,974,600
Natural gas	72,883,000 M cu. ft.	8,357,000
Sand and gravel	1,564,464 short tons	1,334,108
Silver	6,203 troy ounces	5,614
Stone	269,400 short tons	375,438
Unapportioned		56,384
Total value		$14,103,144

[1] According to U. S. Bureau of the Census. Value not included in county total.
[2] Value included with "Unapportioned."

SAN BENITO COUNTY

General Geologic Features. San Benito County is one of the counties of the Coast Ranges, and is located about 100 miles south of San Francisco. Geology of the central Coast Ranges, including San Benito County has been described by Taliaferro.[99] Two of his published sections run from the Pacific Ocean eastward, entirely through this county, to the San Joaquin Valley. His section VI crosses the southern tip of San Benito County entering from the west at a point where the San Andreas fault and the west county line practically coincide. At the San Benito River a synclinal fold in the Cretaceous Asuncion group overlying the Jurassic Franciscan is shown.

To the east is a mass of serpentine, then the New Idria thrust fault, east of which is a succession of Cretaceous and Tertiary sediments. These show steep dips and even slight overturning near the fault, but the easterly dips become more gentle near the edge of the San Joaquin Valley.

His section VII enters the central part of San Benito County at the Pinnacles, showing Miocene volcanic rocks overlying the basement complex of early Paleozoic or pre-Cambrian granite, gneiss, schist, and marble. To the east of the San Andreas fault zone are folding and faulting in Cretaceous and Eocene sediments, including a synclinal fold. Then the section passes through nearly 15 miles of the Jurassic Franciscan, bounded on the east by the Ortigalito thrust fault. Cretaceous and Tertiary sediments extend from this point to the San Joaquin Valley. Dips are steep near the fault but gradually flatten toward the edge of the valley. The dips are to the east except immediately adjacent to the thrust fault.

Anderson and Pack [100] examined the geology of the west border of the San Joaquin Valley in connection with possible petroleum production in 1909-11. Their map shows the geology of about 200 square miles in southeastern San Benito County on a scale of 1:125,000 or about 2 miles to the inch. Cretaceous and Tertiary sediments predominate in the region but a large area of serpentine is shown south of the New Idria quicksilver mine, and small areas of basalt near Llanada.

[99] Taliaferro, N. L., Geologic history and structure of the central Coast Ranges of California: California Div. Mines Bull. 118, pp. 118-163, 1943.
[100] Anderson, Robert, and Pack, R. W., Geology and oil resources of the San Joaquin Valley north of Coalinga, California: U. S. Geol. Survey Bull. 603, 1915.

Geology of the central part of San Benito County has been mapped by Wilson [101] in the San Benito quadrangle, a 15-minute sheet on a scale of 1:62,500 or approximately 1 inch to 1 mile. His report describes the geology and includes a bibliography of the geology of the surrounding region.

The geology of the Pinnacles National Monument has been described by Andrews.[102] It is an area of rocky crags, caves, columns, pillars, and deeply carved canyons on the west border of San Benito County at a point 38 miles south of Hollister. The strange land forms are the result of erosion in a series of Miocene volcanic breccias. The map accompanying Andrews' report shows not only the volcanic formations, but also an equally large area of the basement complex to the west in Monterey County, through which are scattered numerous small lenses (0.1 mile, rarely 0.2 mile in diameter) of the Gabilan limestone.

Table 34. Mineral production from San Benito County during 1947

Product	Quantity	Value
Mercury	9,228 flasks	$772,753
Stone	1,013,980 short tons	[1]
Unapportioned (cement, raw clay, sand and gravel, and stone)		1,724,316
Total value		$2,497,069

[1] Value included with "Unapportioned."

Mineral Resources. San Benito County contains the New Idria mine, currently the largest producer of quicksilver in the United States. Its total production, however, has not yet reached that of the New Almaden mine in Santa Clara County to the northwest. Mineralization is believed to be controlled largely by a fault on which Franciscan rocks of probable Jurassic age are thrust over shales and sandstones of the Panoche formation of Cretaceous age. A number of other quicksilver mines in the county have been productive, including one on the county line between San Benito and Merced Counties, which has also produced some antimony. Crysotile asbestos has been produced and milled in the county near Hernandez. Beds of coal are also known in this vicinity. Large deposits of dolomite are in regular production at a point about 10 miles from Hollister. A rare mineral is benitoite, a gem stone which resembles the sapphire, and which has been described in detail by Louderback.[103] Gypsum has been produced for agricultural use from a deposit 14 miles east of King City, Monterey County, but this production has been discontinued. A very large plant for the production of crushed rock, sand, and gravel is operated near Logan, just inside the boundary line of San Benito County. The granite rock has been crushed by the San Andreas fault, and much less blasting is needed in the quarry than is usually necessary in working granite. Portland cement is produced at a plant near San Juan Bautista. Other mineral resources include barite,

[101] Wilson, Ivan F., Geology of the San Benito quadrangle, California: California Div. Mines Rept. 39, pp. 183-270, 1943.

[102] Andrews, Philip, Geology of the Pinnacles National Monument: Univ. California, Dept. Geol. Sci. Bull., vol. 24, pp. 1-33, 1940.

[103] Louderback, George D., Benitoite, its paragenesis and mode of occurrence: Univ. California, Dept. Geol. Sci. Bull., vol. 5, pp. 331-380, pls. 27-39, 1909.

bentonite, chromite, clay, magnesite, manganese, and mineral water. Small commercial production of petroleum was started in 1948 from the Ciervo anticline near New Idria from depths between 1,100 and 1,200 feet.

C.V.A.

SAN BERNARDINO COUNTY

General Geologic Features. San Bernardino County, containing 20,157 square miles, is the largest county in the state. Of its area approximately 92 percent is desert; the remainder consists of the timbered south slope of the San Bernardino Mountains and a fertile valley which forms a part of the citrus belt of southern California.

The San Bernardino Mountains, in the southern portion of the county, lie within the Transverse Ranges geomorphic province. They are northeast of the San Andreas fault, which here trends N. 60° W. and crosses Cajon Canyon at the west end of these mountains. This mountain range trends eastward from the western boundary of the county approximately 100 miles. Elevations range up to 11,485 feet on San Gorgonio Mountain, 10,630 feet on San Bernardino Peak and 9,842 feet on Sugar Loaf Mountain. At their west end, the south slope is drained by the Santa Ana River, which is fed by numerous creeks. Farther east Mission and Morongo Creeks carry the waters of the south slope into Whitewater River, thence to the Salton Sea.

The core of the San Bernardino Mountains consists of Jurassic acid intrusives of granitic texture. This core is partially capped and flanked by pre-Cambrian, Pennsylvanian, and pre-Cretaceous metamorphics. These altered rocks are predominantly crystalline limestone and quartzite.

The vast desert area of this county is included in the Mojave Desert geomorphic province, which is described by Jenkins[104] as "a broad interior region of mountain ranges, separated by expanses of desert plains. Except for the immediate region of the Colorado River, bordering the province on the east, the drainage is inclosed and playas are numerous. The more prominent trend of the faults is northwest-southeast, while the secondary trend is east-west . . ."

The desert area in the western end of the county lies between the Garlock fault on the north and the San Andreas fault on the south.

"The Garlock fault separates the Mojave Desert on the north not only from the Sierra Nevada but from the Inyo Mountains which represent a part of the Basin-Ranges province . . ."

"The greater part of the Mojave Desert is covered by alluvium, and extensive buried areas are thus concealed. The known geologic conditions of the province, however, indicate that it is underlain largely by metamorphic and igneous rocks, with intervening areas covered by continental sediments, such as lake beds, mud flows and alluvium."

A great variety of rocks is exposed on the desert in San Bernardino County. Unaltered sediments are relatively scarce. Altered sediments range in age from Archean through undivided pre-Cretaceous metamorphics. Igneous rocks are predominantly represented by Jurassic acid intrusives of granitic texture and Mesozoic and Tertiary volcanics, and minor amounts of Quaternary volcanics. The veins in the San Bernar-

[104] Op. cit. (1943).

dino Mountains occur in limestone, quartzite, and the granitic rocks, which form the core of that range. In the desert the gold veins are frequently found in the Tertiary volcanics (usually rhyolite), but are also found cutting partly metamorphosed rocks of pre-Tertiary age and granitic rocks of several different ages.

Mineral Resources. If petroleum and natural gas are not considered, San Bernardino has had the largest mineral production of any county in the state. It is also first in the variety of minerals which have been produced commercially, 38 different species having been marketed from within its boundaries. These include antimony, asbestos, barite, borates, bromine, calcium chloride, clay, copper, dolomite, feldspar, fluorspar, gems, gold, gypsum, iron ore, lead, lithia, limestone, manganese, mineral paint, mineral water, onyx, perlite, petroleum, potash, pumice, quartz, quicksilver, salt, silica, silver, sodium sulphate, strontium, talc, trona, tungsten ore, turquoise, and zinc.

The production of borates from mines in the Calico Mountains, a few miles northeast of Daggett, was for many years the principal industry in the county. These deposits were practically exhausted in 1904, and since that time production of borates in the county has come from the brine of Searles Lake, which is one of the main sources of the world's supply. Calcium chloride is recovered as a by-product in a salt plant on Bristol Lake. Deposits of high-grade clays occur in a number of localities within the county. Copper deposits of commercial value occur sparingly in the mountain ranges of the desert. The most productive mines of the county were the Copper World in the Clark Mountains and the Bagdad-Chase in the Bullion Range about 9 miles south of Ludlow. Gold is widely distributed within its boundaries. Its recorded production from 1880 through 1947 amounted to $11,908,581. On the north slope of the San Bernardino Mountains are situated the Bear Valley, Black Hawk, Holcomb Valley, and Morongo districts, in each of which some gold has been mined. In the desert the more important districts are the Arrowhead, Dale, Goldstone, Gold Reef, Ivanpah, Ord, Oro Grande, Steadman, Twenty-Nine Palms, and Vanderbilt. Of these, the Dale, in which the Supply mine is located, the Steadman, with the Bagdad-Chase mine, and the Vanderbilt, containing the Vanderbilt mine, have been the most productive. Deposits of iron ore occur in the Lava Bed district, Silver Lake district, Cave Mountains, Marble Mountains, Providence Mountains, and Ship Mountains. Cave Canyon deposits are half a mile north of Baxter. These are contact-metamorphic replacement deposits in limestone at or near its contact with diorite porphyry. Shipments of 30,000 to 60,000 tons per year are made from these deposits for use in the manufacture of cement. Vulcan deposit is 9 miles south of Kelso, a station on the Union Pacific Railroad. The ore bodies are replacements in limestone which have been intruded by monzonite. This deposit has supplied most of the iron ore used in the blast furnace of the Kaiser Company at Fontana. The production of lead from the county has not been great. Currently the Mohawk mine, on the south slope of Clark Mountain about 24 miles north of Cima, is the third largest producer in the state. The ore bodies occur at the intersection of northwest and east-trending fissures in limestone. There are numerous large deposits of limestone in the county of a grade suitable for industrial use. Several of these are so conveniently situated with respect to transportation and centers

of population that they have been quarried, the limestone being used in building materials and other products for which it is suitable. There are three cement plants in the county, one each at Colton, Victorville, and Oro Grande. The two first mentioned have operated continuously for many years. The Colton plant started production in 1891. Potash is produced from the brine of Searles Lake by the American Potash and Chemical Company at Trona. Salt is produced from a crystalline body 5 feet thick underlying the surface of Bristol Lake, 3 miles east of Amboy.

The recorded production of silver from the county 1880-1947 has amounted to $29,851,304. Principal production has come from the Calico and Rand districts. The ore bodies of the Calico occur in a fractured and highly brecciated rhyolite porphyry. The mines of this district produced several million dollars from 1880 to 1900. In the Rand district, at Red Mountain, the Kelly, California-Rand or Kelly Gold and Silver mine, as it has variously been called, has produced more than half of the recorded silver production of the county. The ore bodies occur in veins in the Rand schist, and, in some large stopes, 70 feet to 80 feet wide, averaged 76 ounces of silver per ton.

Soda ash and trona are produced in two plants from the brine of Searles Lake. Sodium sulphate is produced from Searles Lake and Dale Lake, which is some 30 miles south of Amboy. In the aggregate large tonnages of talc have been shipped from the Kingston Mountains east of Tecopa and the Shadow Mountains some 10 miles northeast of Silver Lake. While accurate statistics are not available, it is believed that the scheelite veins and placer deposits at Atolia have produced approximately $20,000,000 (?) in tungsten ores. These deposits have been worked since 1905. Principal production of zinc has come from the Ivanpah and Clark Mountains in the eastern end of the county. In each of these areas the ore bodies occur in fractures in limestone.

Table 35. Mineral production from San Bernardino County during 1947

Product	Quantity	Value
Calcium-magnesium chloride	7,968 short tons	$111,950
Clay, raw	63,491 short tons	232,206
Coke	332,244 short tons	[2]
Copper	92,000 pounds	19,320
Gold	4,409 troy ounces	154,315
Iron: Ore	346,545 long tons	[1]
Pig	453,376 short tons	[2]
Lead	158 short tons	45,504
Lime	31,457 short tons	328,329
Salt (sodium chloride)	150,293 short tons	386,742
Sand and gravel	1,151,258 short tons	1,124,251
Silver	103,877 troy ounces	94,009
Stone	558,580 short tons	827,992
Talc	46,535 short tons	997,446
Zinc	650 short tons	157,300
Unapportioned (boron minerals, bromine, cement, iron ore, lithium minerals, petroleum, potassium salts, silica [quartz], sodium salts, and tungsten concentrates)		32,220,545
Total value		$36,699,909

[1] Value included with "Unapportioned."
[2] U. S. Bureau of Mines not at liberty to publish figure. Value not included in county and state totals.

Significant Activities During 1947. The American Potash and Chemical Corporation at Trona on Searles Lake continuously produced, in its recently enlarged plant, borates, potash, and soda ash from the brine of the lake. The West End Chemical Company's plant on the shore of the same lake continued its production of borates and soda ash. Shipments of iron ore to the cement plants from the Cave Cayon deposits were made as usual during the year. The Kaiser Company at Fontana, having added to its plant a pipe mill, cold-roll mill and cold-draw mill for rounds, flats, squares, and hexagonals, continued its operations, getting its iron ore from the Eagle Mountain deposits in Riverside. The principal lead producer in the county, the Mohawk mine in the Clark Mountains, continued its shipments during 1947. Discovery of silver in the Silurian Hills, some 14 miles north of Baker, by the Silver Hills Mining Company, resulted in shipment of some high-grade chloride ores and the continued exploration of the property. The plant of the Dale Chemical Company on Dale Lake has been taken over by the Dale Chemical Industries, Inc. This company has started year-around production of sodium sulphate. Production of talc from the Kingston Mountains and the shadow Mountains was continued by the Sierra Talc Company, the Southern California Minerals Company and the Western Talc Company. The Mohawk mine in the Clark Mountains and the Carbonate King mine in the Ivanpah Mountains continued their shipments of zinc ore during 1947. Shipments of limestone from the Chubbuck deposits in the eastern part of the county continued through 1947. Some of the material has been used in the open-hearth furnaces of the Kaiser steel plant at Fontana. R.J.S.

SAN DIEGO COUNTY

General Geologic Features. San Diego County, lying almost wholly within the Peninsular Ranges geomorphic province of California, is an area of diversified physiography. A relatively narrow belt of terraces or mesas along the Pacific Ocean flanks the 50-mile-wide zone of northwest-trending parallel mountain ranges, which are the northern extension of the Peninsular Ranges of Baja California. A desert area, part of the Salton Basin, borders the eastern part of the county and is reached by an abrupt descent from the highlands in contrast to the comparatively gentle slope of the mountains on the west. Major streams which cut the coastal belt and head in the back country of the highlands are the Santa Margarita, San Luis Rey, San Dieguito, San Diego, Sweetwater, Otay, and Tia Juana Rivers. Their valleys are characterized by steep sides.

The coastal belt consists essentially of relatively flat, high, mesas extending from the mountains and ending as cliffs along most of the shoreline except in the San Diego Bay region. These wave-cut terrace remnants were developed successively in late Tertiary and Quaternary time as shown by differences in elevations of the old shorelines. The rocks of the coastal belt which have been exposed by erosion or wave action are mainly Eocene with some Pliocene and Pleistocene marine sediments. Underlying the sediments are early Mesozoic metavolcanics, largely andesite, which have been intruded by acidic plutonic rocks. The metavolcanics are well exposed in the foothills east of Vista and extend several miles to the south.

The mass of mountain ranges in the central part of the county are great composites of crystalline rocks and metasediments. Late Paleozoic

and Triassic schist, quartzite, slate, and crystalline limestone are closely associated with the intrusive gabbro, tonalite, and granodiorite of Cretaceous age. The fact that individual crystalline masses are seldom more than 6 to 8 miles in diameter adds to the complexity of the geologic picture. Associated with the crystalline intrusives are numerous pegmatite dikes, the source of the gem stones for which San Diego County is famous.

Traversing the northeastern section of the county are three major faults, the Elsinore, Agua Caliente, and San Jacinto, which strike generally in a northwestward direction. The first of these is the most southwestward of the group and passes a few miles east of Pala as it enters the county from the Elsinore Valley region. The land forms developed in this region and particularly along the northeastern border represent structural basins, such as Borrego Valley, flanked by crystalline masses. Further to the south and southeast in the desert section are exposures of Miocene and later nonmarine sediments, underlain by granitic rocks.

Early geological studies of San Diego County were made by Goodyear [105] and Fairbanks [106] during their reconnaissance surveys. Merrill [107] emphasized the mineral resources of the county in his work. Ellis and Lee [108] made a thorough study of the geology of the western part of San Diego County as related to ground water. Hudson,[109] Hanna,[110] Hertlein and Grant,[111] and Miller [112] are among others who have contributed; more recent work has been done by Larsen.[113]

Mineral Resources. San Diego County is endowed with a large variety of commercial minerals but the major production has been that of the structural and industrial minerals groups. Of these materials, sand, gravel, granite, brick and building tile, gems, salt and mineral water have been most important. Metal production has consisted largely of gold and silver.

The principal gold-producing area of the county is a zone extending approximately 45 miles from the Montezuma district east of Warner, to the southern border. The largest production has been from the Julian-Banner district, located at about the geographical center of the county. The lenticular gold-bearing quartz veins occur principally in a metamorphosed granodiorite, with some occurrences in the Julian schist. Approximately 4 to 5 million dollars have been produced from the mines of the district.[114] Gold placer deposits are located in the stream areas east of Ramona and near Julian. Nickel is found in the sulphide ore bodies in the Julian-Pine Hills district, 3 miles south of Julian. The

[105] Goodyear, W. A., San Diego County: California Min. Bur. Rept. 8, pp. 516-528, 1888.

[106] Fairbanks, Harold W., Geology of San Diego County; also of portions of Orange and San Bernardino Counties: California Min. Bur. Rept. 11, pp. 76-120, map, 1893.

[107] Merrill, Frederich J. H., San Diego County: California Min. Bur. Rept. 14, pp. 635-722, 1914.

[108] Ellis, A. J., and Lee, C. H., Geology and ground waters of the western part of San Diego County, Cal.: U. S. Geol. Survey Water-Supply Paper 446, 321 pp., 1919.

[109] Hudson, Frank S., Geology of the Cuyamaca region of California, with special reference to the origin of nickeliferous pyrrhotite: Univ. California Dept. Geol. Sci., Bull. 13, pp. 175-252, 7 figs., 6 pls., map, 1922.

[110] Hanna, Marcus A., Geology of the La Jolla quadrangle, California: Univ. California Dept. Geol. Sci., Bull. 16, pp. 187-246, 7 pls., 1 map, 1926.

[111] Hertlein, Leo G., and Grant, U. S. IV, Geology and oil possibilities of southwestern San Diego County: California Div. Mines Rept. 35, pp. 57-78, 1939.

[112] Miller, William J., A geologic section across the southern Peninsular Range of California: California Div. Mines Rept. 31, pp. 115-143, map, 1935.

[113] Larsen, Esper S., Batholith and associated rocks of Corona, Elsinore, and San Luis Rey quadrangles, southern California: Geol. Soc. America Mem. 29, 1948.

[114] Donnelly, Maurice, Geology and mineral deposits of the Julian district, San Diego County, California: California Div. Mines Rept. 30, pp. 331-370, 1 map, 1934.

2 to 3 percent nickel mineralization, associated mainly with pyrrhotite and pentlandite, has not been sufficient to warrant commercial production to date. During World War II, tungsten deposits were prospected in the areas east of Palomar Mountain, northeast of Pine Valley and north of Jacumba. The tungsten occurs as scheelite in tactite. Minor amounts of lead, copper, and arsenic have been produced in the county in the past.

Extensive deposits of sand and gravel found throughout the county are used in the production of sand, gravel, and crushed rock for building purposes. Quartzite pebbles, of secondary origin from sedimentary beds, are mined along the beaches of Encinitas and Carlsbad for use as grinding and filter media. Clay deposits in the Eocene beds in Rose Canyon, north of San Diego, Encinitas, Carlsbad, and Olivenhain areas supply materials for the old established clay brick and tile manufacturing plants. Clay sands of the coastal belt near Oceanside are worked for sand blasting, filtering, and plaster aggregate materials. Montmorillonite clay for filtering purposes is found in the Otay Mesa area. Extensive clay beds in the eastern desert area of the county remain to be developed. Gypsum, another important building material, is likewise found in rather large deposits in the desert country along the eastern border, but production has been from the adjacent deposits in Imperial County to date. San Diego granite, actually a gabbro, is the source of excellent building and monumental stone. Quarries located in the Lakeside, Escondido, and Pala areas produce varieties ranging from dark or black granite to light, silver-gray. Both the black and silver-gray varieties of the San Marcos gabbro produce monuments and building stone of distinct beauty.

One of the few important pyrophyllite deposits in California is located near Escondido. The mineral, an alteration product of andesite, is used principally as a carrier for various insecticidal dusts.

The world-famous gem deposits of San Diego County are found in the pegmatite dike areas of the Pala, Rincon, Mesa Grande, Ramona, and Jacumba areas. In addition to the gem minerals, topaz, beryl, tourmaline, garnet, and kunzite, several other commercial minerals are associated with the pegmatites. Lepidolite (lithium mica), feldspar, scrap mica, and silica have been produced on a commercial scale. The largest of the feldspar deposits is located near Campo and was operated for several years.

San Diego County has been a producer of salt for many years. Solar evaporation is used to recover common salt from the ocean waters of San Diego Bay. The residual bitterns from the salt operation are the source of soluble salts of calcium and magnesium. Mineral springs are found in all sections of the county, ranging from cold springs to thermal springs of high temperatures. Many are utilized for resort purposes and others for domestic and bottled water.

Other mineral deposits having commercial possibilities and worked in the past include strontianite, kaolin, optical calcite, and greenstone. Volcanic ash, andalusite, sillimanite, and iron ore deposits are likewise found in the county and may offer possibilities for future development and utilization.

Table 36. Mineral production from San Diego County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[1]
Clay, raw	14,533 short tons	$15,005
Gold	13 troy ounces	455
Sand and gravel	1,195,011 short tons	1,324,830
Silver	6 troy ounces	5
Stone	79,410 short tons	196,037
Unapportioned (magnesium compounds, pebbles for grinding, pyrophyllite, and salt)		346,062
Total value		$1,882,394

[1] U. S. Bureau of the Census not at liberty to publish figure. Value not included in county total.

Significant Activities During 1947. Value of mineral production in San Diego County amounted to more than 2 million dollars, or about 5 percent of the total natural resources production of the county in 1947. About two-thirds of this was in sand (building, blasting, and moulding), gravel, and crushed rock. Building and monumental granite and clay products, including common brick and clay and adobe brick were other large contributors to the total production. Metal mining was almost entirely dormant during the year.

New grinding equipment and milling facilities were installed at the Chula Vista plant of the Pioneer Pyrophyllite Company and production was increased considerably over the 1946 figure. Pyrophyllite has enjoyed wide use as a carrier for insecticidal dusts, particularly those containing DDT.

The clay brick and tile industry continued production on a high level to meet the building industry's requirements. These products as well as adobe brick are consumed largely in residential construction although some goes into industrial buildings. A few hundred tons of montmorillonite was produced from the Otay Mesa area during the year. Improvements at the plant of the Crystal Silica Company near Oceanside have resulted in increased production of sand blasting, filter, and plaster sands from the clay-sand deposits of the area. A small tonnage of grinding and filter pebbles, once produced in fairly substantial quantities, was reported.

Renewed activity in gem mining has resulted from the reopening of the Sickler group of claims on Heriart Hill near Pala by George Ashley. This operation together with others started and contemplated may bring San Diego County again into prominence as a gem-producing center.

Production of common salt by the Western Salt Company at its plant in the southern part of San Diego Bay was continued at a rate comparable to previous years. Improved haulage equipment was added during the year. The residual bitterns of the operation are processed by the Westvaco Chemical Company in the production of agricultural and industrial chemicals. L.A.N.

SAN FRANCISCO COUNTY

General Geologic Features. San Francisco County, situated on the south side of the Golden Gate, contains the smallest area and the

largest population density of all the counties in California. The former is 45 square miles and the latter was 17,950 persons per square mile in 1947. San Francisco has given its name to a group of rocks extensively distributed throughout the Coast Ranges of California and widely exposed in this county.[115] This group, known as the Franciscan formation (Jurassic), includes sedimentary beds, intrusive and extrusive igneous bodies, and crystalline schists resulting from the metamorphism of the igneous and sedimentary members.

The sandstone is over 2,500 feet thick, usually massive, well cemented, and arkosic, with obscure bedding planes. Beds of gray foraminiferal limestone averaging 60 feet thick appear about 500 feet above its base. The limestone is stratified and contains dark and light-colored lenses of chert ranging from 1 inch to 1 foot in thickness. Bold outcrops of hard, thin-bedded, reddish-brown radiolarian chert are common throughout the county, especially near Ingleside, where it attains a thickness of more than 500 feet. The chert section is customarily made up of alternating layers of chert averaging 2 inches in thickness, separated by sheets of shale averaging a quarter of an inch in thickness. In some instances, however, the shale partings are absent and the chert assumes a massive appearance.

Two types of igneous rocks have been intruded into the sedimentary series, namely: peridotite, now altered to serpentine; and ellipsoidal basalt. Serpentine outcrops in a belt about half a mile wide extending diagonally across San Francisco from Hunters Point northwestward to the Golden Gate. The serpentine is sheared, slickensided, and in the Potrero district includes lenses of fine-grained diabase. The ellipsoidal nature of the basalt can be seen in the cliff exposures at Hunters Point.

Local metamorphism of the igneous and sedimentary rocks has formed crystalline schists in discontinuous border zones on the periphery of the intrusive bodies, particularly the serpentine. These metamorphic rocks are characterized by blue amphibole and are termed "glaucophane schists;" but mica schist, quartz schist, albite schist, and numerous subdivisions are also found. No Cretaceous beds have been mapped in this county. Merced sediments of Pliocene age south of Lake Merced form the sole outcrop of Tertiary rocks. Quaternary beach sands drifting eastward from the Pacific shore have formed a mantle of sediment over the areas of low elevation north of Mount Davidson and the San Miguel Hills. South of these hills the low areas are covered with alluvium.

Structurally, San Francisco County is located on the uplifted west side of a fault-block which trends northwestward and is tilted to the northeast. The San Bruno fault strikes northwestward in the southwestern corner of the county where it has been mapped along the east shore of Lake Merced, a drowned river valley cut off from its outlet to the sea by drifting beach sands.

Mineral Resources. San Francisco County is usually considered a center of finance, distribution, and consumption for the mineral industry, rather than a producer of mineral products. Nevertheless, occurrences of more than 30 different minerals have been noted in the county and some minerals are produced each year. The total value of this production has reached the substantial sum of $9,000,000 during the period of sta-

[115] Lawson, A. C., U. S. Geol. Survey Geol. Atlas, San Francisco folio (no. 193), 1914, 1914.

tistical history which began in 1894. The production list includes: asphalt, clay, gold, mineral water, foundry sand, and miscellaneous stone. Miscellaneous stone (crushed rock, sand, and gravel) has accounted for most of the production. The crushed rock has been produced from metamorphosed blue sandstone, chert, and jasper of the Franciscan formation. Brown dune sand is supplied to local foundries and a few ounces of gold are produced annually from sands along the ocean beach. A small amount of mineral water is produced annually. Clay for brick-making was produced prior to 1910, and asphalt was produced during the same period. Previous to the establishment of the Lake Merced golf course, that site was the source of volcanic ash used in soap-making by a local company.[116]

Significant Activities During 1947. A few ounces of gold were recovered by itinerant prospectors from beach sands along the sea coast between Lake Merced and the county line.

Brown clay-free sand suitable for large foundry cores, is obtained from the sand dunes along the western edge of the city. A heavy red clay-bearing moulding sand is obtained from building excavations in the Mission district.

Crushed rock is produced in moderate quantities at the Mission quarry from a hard, gray, metamorphosed sandstone. F.F.D.

SAN JOAQUIN COUNTY

General Geological Features. San Joaquin County is located in the center of the Great Valley of California where the San Joaquin Valley from the south merges with the Sacramento Valley from the north. A delta tidal plain, composed of islands separated by sloughs of the meandering San Joaquin and Mokelumne Rivers, occupies a large part of the area west of Stockton. Many of these fertile islands are slightly below sea level and artificial levees protect them from invasion by the sloughs. Eastward from the delta an alluvial plain rises to the foothills of the Sierra Nevada. These two plains are blanketed by Quaternary alluvium (sand, silt, and gravel) which covers about 70 percent of the county area.

A succession of Quaternary and Tertiary sediments with a slight westerly dip outcrop in a foothill belt along the eastern boundary of the county. The foothills extend beyond the county line and the sediments overlie the older rocks of the Sierra Nevada. The youngest sediments in the succession are Quaternary to upper Pliocene in age and have been described as the Laguna formation.[117] They consist of obscurely bedded, non-andesitic, fluviatile silt and sand, with some clay and gravel. Continuing eastward the Laguna is in contact with the Mehrten formation of upper Miocene age. The Mehrten is composed mainly of volcanic detritus in well-sorted, well-stratified, fluviatile sandstone, siltstone, and conglomerate. It includes layers of coarse mud-flow agglomerate and is dominantly of andesitic composition.

The central Coast Ranges of California cut across the southwest corner of San Joaquin County. Westward through the foothills from the valley floor, the first formations encountered are Quaternary-Pliocene

[116] Laizure, C. McK., San Francisco County: California Div. Mines Rept. 25, pp. 242-245, 1929.

[117] Piper, A. M., Gale, H. S., Thomas, H. E., and Robinson, T. E., Geology and ground water hydrology of the Mokelumne area, California: U. S. Geol. Survey, Water-Supply Paper 780, 1939.

fluviatile sandstones and gravels. These gravels attain a thickness of more than 2,300 feet and at their western margin are in fault contact with both Upper Cretaceous and upper Miocene beds; the upper Miocene overlies the Upper Cretaceous north of Corral Hollow Creek. In the southwestern corner of the county the Franciscan formation of Jurassic age is exposed.

Mineral Resources. Gold and manganese ore of the metal group, natural gas of the fuels, and clay, sand and gravel of the industrial nonmetallic group, constitute the principal mineral resources on the San Joaquin County production list. Clays suitable for making brick and some red clay products are present in large amounts and have been mined in the vicinity of Stockton for many years. Gold is recovered from the channels of the Mokelumne River where the latter traverses the foothills of the Sierra Nevada in the eastern part of the county. Silver and platinum are produced as by-products of gold dredging. Manganese ore has been produced intermittently since 1867 from the Ladd mine in sec. 2, T. 4 S., R. 4 E. The ore body at this mine is pancake-shaped and lies parallel to the bedding in chert of the Franciscan formation. The primary ore is rhodochrosite which is altered to black oxides. Natural gas has been produced from wells in the vicinity of Stockton since 1894. The McDonald Island gas field, 2 miles northwest of Stockton, was discovered by a reflection seismograph survey and the first well was completed in June 1936 from a lower Eocene sand at a depth of 5,153 feet. There are now 7 producing wells in the field. One of the two producing gas wells in the Vernalis field is located in the southwestern part of the county. It produces from Cretaceous sands at a depth of about 4,750 feet.

Commercial delivery of gas began from the Lodi gas field in 1946 although the discovery well, located in sec. 9, T. 4 N., R. 7 E., M. D., was completed in 1943.[118] There are now four wells producing from the Nortonville (Eocene) sand at a depth of about 2,500 feet. Initial potential production was indicated at a rate of more than 7,000 Mcf per day. The discovery well of the Thornton gas field, in sec. 38, T. 5 N., R. 5 E., M. D., was also drilled in 1943. This gas field is in both Sacramento and San Joaquin Counties. Indicated potential gas production was at the rate of about 7,000 Mcf per day from Capay (Eocene) sand. There are nine potential wells in the field. Sand and gravel is produced from Recent deposits at numerous points throughout the county.[119]

Significant Activities During 1947. Clay products (brick and hollow building tile) and a moderate amount of crude clay were produced by four companies with plants located at Stockton. The other clay products include pottery dinnerware, bisque doll bodies, sewer pipe, terra cotta pipe, stoneware, porcelain electrical supplies, and other items classed as miscellaneous. Crude clay was produced by the Pacific Clay Products Company and the San Joaquin Brick Company from open pits by means of draglines. About 60 percent of this crude clay was used in brick making.

The lower Camanche dredge of the Gold Hill Dredging Company has been operating above the Clement bridge on the Mokelumne River. This dredge, constructed at Loomis, was shipped to the Mokelumne in 1940. It was shut down for 10 months in 1943 because of wartime restric-

[118] California Div. Oil and Gas, Annual Report of the State Oil and Gas Supervisor, vol. 33, no. 2, pp. 70-71, 1947.

[119] Laizure, C. McK., San Joaquin County: California Div. Mines Rept. 21, pp. 184-200, 1925.

tions, but resumed operations in 1944 and worked continuously until March 1948. When the irrigation season has passed the dredge will be moved south of the bridge. This is a bucket-line dredge with a riveted-steel hull and 78 buckets of 9 cubic feet capacity, capable of digging at the rate of 23 buckets of gravel per minute. The maximum digging depth is 40 feet below the water-line where a bedrock of volcanic ash is encountered, but economic conditions usually limit dredging to a depth of 25 feet. There is no clay and no stripping problem. The gravel is not cemented, is fine to medium in size, but there are a few boulders more than 6 inches in size. As dredging proceeds downstream the gold becomes finer and decreases in amount away from the channel. The gold is not rusty and recovery is made with a 60-foot trommel, twelve Pan-American jigs, and two Titan amalgamators. Cocoa matting and expanded metal plates are used in the sluices in lieu of riffles. The dredge is electrically operated, runs on two shifts, and employs a total of 20 men. This dredge performs an economic service to many local farmers harassed by mortgaged farms. Dredging the unproductive land provides the farmer with a dependable income with which he can eliminate his mortgage, rehabilitate his potentially productive land, or begin anew in a more favorable locality.

Natural gas is produced at the rate of 10,000,000 Mcf per year from four small gas fields in the San Joaquin Valley. The Tracy gas field is operated by the Amerada Petroleum Corporation. There are two wells producing from Cretaceous sands at a depth of 4,000 feet. At the McDonald Island gas field 10 miles northwest of Stockton, the Standard Oil Company has seven wells producing from Eocene sands at a depth of 5,300 feet. Both fields are northwestward-trending anticlines and were located in 1935 by reflection seismograph surveys. Commercial deliveries of gas from the Lodi and Thornton gas fields began late in 1946.

A modern sand and gravel plant has been erected and put into operation west of Tracy by the Pacific Coast Aggregates Company. It is composed of four parts, namely: an excavating-storage unit, a unit producing unwashed road rock, a washed sand and gravel unit, and a crushed rock unit. Each part may be operated independently. The company owns a large gravel deposit which has been tested to a depth of 100 feet. Very little stripping is required and ample water is available from shallow wells. Mining the deposit is a pit operation. A Northwest dragline, equipped with a 2½ cubic yard bucket, digs from a 50-foot bank and dumps to a mobile field hopper set in the pit. The hopper discharges to a 36-inch pit conveyor belt, delivering the crude aggregates to the primary storage pile. Sand and gravel is also mined in the Riverbank area.

A new plant for the production and sales of lightweight (pumice aggregate) and concrete products has been constructed by the Basalt Rock Company, Inc., on Highway 50 south of Stockton. This plant will make blocks, precast structural sections, and pipe, using crude products shipped in from company-owned deposits.

A new plant for the production of concrete pipe products is under construction on the east edge of Stockton by the United Concrete Pipe Company. The aggregate for these products will be furnished by gravel companies operating on dredge tailing in the northeastern part of the county. F.F.D.

Table 37. Mineral production from San Joaquin County during 1947

Product	Quantity	Value
Clay product, heavy clay (other than pottery and refractories)		[1]$291,000
Natural gas	9,650,000 M. cu. ft.	1,261,000
Sand and gravel	1,598,607 short tons	1,330,544
Unapportioned (raw clay, gold, silver, and stone)		340,876
Total value		$2,932,420

[1] According to U. S. Bureau of the Census. Value not included in county total.

SAN LUIS OBISPO COUNTY

General Geologic Features. San Luis Obispo County is one of the coast counties and is a mountainous region, of which the Santa Lucia Range, a part of the Coast Ranges, is a prominent feature. The mountains are composed of a basement complex of granite, gneiss, schist, and marble of early Paleozoic or pre-Cambrian age, extensive masses of Franciscan sediments, and a series of Cretaceous and Tertiary sediments. The whole is intricately folded and faulted. The eastern boundary of the county zigzags along the San Andreas fault, practically following it. Other nearly parallel faults, striking northwestward, pass through the center of the county and near the coast. Extensive intrusive bodies of ultrabasic rocks, also striking northwestward, are associated with Franciscan sediments near the town of San Luis Obispo. Tertiary intrusive rocks and Tertiary volcanic rocks are found in the southwestern part of the county.

Mineral Resources. San Luis Obispo County contains a wide variety of mineral resources, and during some of the war years mineral production amounted to more than $1,000,000 a year; but prices for some of its products such as chromite, manganese, and quicksilver, went down after the end of the war, and production has declined. Low-grade chrome ore was mined at the Castro mine near San Luis Obispo from deposits in the ultrabasic rocks, and concentrated to a marketable grade. Quicksilver has been produced extensively from two main sections; one in the northwest corner of the county includes the Oceanic and Klau mines; the other in the central part southeast of Santa Margarita includes the Rinconada and Deer Trail mines. The county has produced more than 5,000 tons of manganese ore from deposits in Franciscan chert along a belt about 60 miles long in the western part. Local clay is produced for making brick and tile, and for oil-well drilling mud. Limestone for beet-sugar refining is produced from Lime Mountain in the northwestern part of the county. Shells found here indicate a Miocene age.[120] A number of other limestone deposits have been worked in former years. The county has been a minor producer of petroleum for many years from the Arroyo Grande field near the coast about 12 miles south of San Luis Obispo. Enormous deposits of dry tar sand or bituminus rock occur near this field. Years ago some of this was mined for paving roads. Mineral springs near Paso Robles are utilized in connection with resorts. Soda Lake in the arid Carrizo Plain of the southeastern part of the

[120] Logan, Clarence A., Limestone in California: California Div. Mines Rept. 43, p. 304, 1947.

Table 38. Mineral production from San Luis Obispo County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[1]
Mercury	449 flasks	$37,599
Unapportioned (raw clay, petroleum, sand and gravel, and stone)		358,794
Total value		$396,393

[1] U. S. Bureau of the Census not at liberty to publish figure. Value not included in county total.

county contains a large reserve of crude sodium sulphate. The lake has no outlet and is dry except after heavy storms. Other mineral resources of the county include antimony, copper, diatomite, dolomite, gold, iron ore, molding sand, oil shale, onyx marble, miscellaneous stone, and volcanic ash.

Significant Activities During 1947. An oil well in sec. 25, T. 11 N., R. 28 W., S. B., in Cuyama Valley, was completed on January 2, 1948, for an initial production of 150 barrels of 20° oil per day. The well was drilled by Norris Oil Company, and is about 1,900 feet deep. This is the first commercial production from the southeastern part of the county. Additional wells developed later in 1948 both in this county and just across the line in Santa Barbara County to the south make this one of the outstanding discoveries of recent years. Production of limestone for use in the beet-sugar industry was greatly expanded in 1947 at the Lime Mountain deposit, 26 miles southwest of San Miguel. C.V.A.

SAN MATEO COUNTY

General Geologic Features. The most important structural feature of San Mateo County is the San Andreas fault zone. At some localities it comprises two or more parallel fractures [121] a mile or more apart, while at other localities it is represented by a crushed zone half a mile in width. A series of northwest-trending depressions such as Crystal Springs Lake, West Union Creek, Corte de Madera Creek, and Stevens Creek, lie along the line of faulting. The strike of the fault zone is approximately N. 45° W., and in general it divides the county into two separate geologic areas. Although Quaternary movement along the San Andreas has been essentially horizontal, the ancestral San Andreas produced large vertical movements. Upper Cretaceous rocks and rocks of the Jurassic Franciscan formation outcrop in the upthrown block on the northeast side of the fault zone. The Franciscan formation consists of arkosic sandstone, shale, chert, and associated basic intrusives altered to serpentine. In the northern part of the county Jurassic ultrabasic intrusives are found along the fault zone. Massive Eocene sandstone; Miocene sandstone, conglomerate, and diatomaceous shale; and Pliocene sandstone and shale are prevalent in the downthrown block southwest of the fault zone. Miocene diabase and basalt in the form of intrusives, flows, and tuffs, occur in vicinity of Langley and Mindego hills east of La Honda. The west slope of Cahil Ridge, about 2 miles southwest of the San Andreas fault,

[121] Branner, J. C., Newsom, J. F., and Arnold, Ralph, U. S. Geol. Survey Geol. Atlas, Santa Cruz folio (no. 163), 1909.

is the locus of another northwest-trending fault. Here, again, the downthrown block is on the southwest side of the fault. At its northern extremity this fault brings a mass of quartz diorite (Montara mountain) into contact with the Franciscan formation. The San Gregorio fault, trending northwestward, is located 15 miles southwest of the San Andreas fault. The Pliocene sediments of the downthrown block on the southwest side of the fault are in contact with Miocene Monterey shale on the northeast side of the fault. Sandstone and conglomerate of the Chico formation (Upper Cretaceous) outcrop along the coast south of Pescadero Point.

Mineral Resources. The value of San Mateo County mineral production since 1895 has reached the total of approximately $60,000,000. This total has been derived chiefly from cement, clay, limestone (oyster shells), magnesium salts, salt, and miscellaneous stone. Clay for brick-making was produced for 19 years beginning in 1898, and clay is now produced for the manufacture of cement. The lime necessary for cement is provided by extensive deposits of oyster shells found on the bottom of San Francisco Bay. The area covered by oyster beds exceeds 30,000 acres and extends across the channel between Millbrae and Alviso. Magnesia, magnesium hydroxide, and magnesium carbonate are produced from sea water at South San Francisco. Salt has been produced from sea water south of San Mateo at a plant which was established in 1901. Foundry sands have been produced and blended in the eastern part of South San Francisco. Ordinary sand has been produced from the beaches along the western shore. The hard gray metamorphosed sandstone of the Franciscan formation has been the source material in many crushed rock plants and has been used for curbing in some localities. Small amounts of the following minerals have been produced: Gems, granite, natural gas, petroleum, potash, and sandstone.[122].

Significant Activities During 1947. Cement in large volume is produced at the plant of the Pacific Portland Cement Company situated at tidewater in Redwood City. The raw materials, clay and lime, are obtained from extensive deposits of clay and oyster shells found on the floor of San Francisco Bay, adjoining the plant. The clay and shells are withdrawn from the bay and delivered to barges by suction dredges operating through 16-inch pipes. A fleet of four tugs and ten barges transport the crude material to the unloading wharf where it is removed by an overhead crane and bucket, and sent to the raw-grinding storage bins. The cement is produced by the wet process in four 10- by 240-foot rotary kilns. An adjoining plant has a capacity of 150,000 square feet of wallboard or sheet rock per day.

Magnesium compounds are produced by the Marine Magnesium Products Corporation at South San Francisco and by the Plant Insulation Company at Redwood City. Sea water is the raw material. Magnesium hydroxide, formerly precipitated by lime derived from limestone or oysters shells, is now precipitated by calcined dolomite. In this way the normal output of the plant is increased by the magnesia content of the dolomite.

An extensive deposit of moulding sand has been exposed west of Millbrae in a quarry originally opened to provide fill-rock. The sand is mined by shovel, trucked to South San Francisco, reduced to minus $\frac{1}{8}$ inch, and blended with clay to meet foundry requirements. A "heavier"

[122] Senior, S. P., Jr., San Mateo County: California Div. Mines Rept. 25, pp. 245-259, 1929.

moulding sand is produced in the hills east of South San Francisco in a similar manner. The deposits are worked by the Brumley-Donaldson Company.

Large quantities of crushed rock, much of it used as fill material, have been produced in this county in recent years. Hard metamorphic sandstone, chert, and some limestone have been the source rocks for this production. Important quarries are located at Belmont, Brisbane, Daly City, Half Moon Bay, Millbrae, South San Francisco, Rockaway Beach, and Woodside. F.F.D.

Table 39. Mineral production from San Mateo County during 1947

Product	Quantity	Value
Stone	1,078,700 short tons	$1,184,602
Unapportioned (cement, magnesium compounds, and sand and gravel)		4,149,422
Total value		$5,334,024

SANTA BARBARA COUNTY

General Geologic Features. Santa Barbara County, containing 2,740 square miles, is one of the coastal counties and is largely hilly and mountainous. The Cuyama River forms the natural boundary between Santa Barbara and San Luis Obispo Counties. To the south, the Santa Ynez River flows through the entire width of the county just north of the Santa Ynez Mountains.

The basement of the entire county is Franciscan, exposed locally as glaucophane schist, serpentine, sandstone, and shale. Overlying the Franciscan in the San Raphael Mountains are Cretaceous marine sediments and unconformably over these are highly folded Eocene and Miocene marine sediments. The Nacimiento fault on the northeast flank of this range is a major fault extending into the ocean off Monterey County.

The Santa Ynez Mountains, largely anticlinal [123] show the same general folded stratigraphic units with some Miocene volcanics exposed at the western end just east of Point Arguello. A strong east-trending fault extends along the north flank of this range into Ventura County. The southward-dipping homoclinal structure of the south flank of this range is broken along the coastal plain by several faults and small east-trending anticlinal folds,[124] the latter being rather important oil structures.

The lower hills in the western part of the county, covered largely with Quaternary sediments, contain several series of anticlinal folds and domes which are productive oil structures. Stratigraphically, the moderately folded Franciscan basement rock is covered unconformably by Tertiary to Recent sediments.

Mineral Resources. Santa Barbara County has produced asphalt and bituminous rock, clay, diatomaceous earth, gypsum, limestone, sandstone, oil, shale, miscellaneous stone products, mineral water, copper, chromite, gold, silver, quicksilver, and petroleum and natural gas.[125]

[123] Fairbanks, H. W., Geology of northern Ventura, Santa Barbara, San Luis Obispo, Monterey, and San Benito Counties: California Min. Bur. Rept. 12, pp. 493-526, 1894.

[124] Hill, Mason L., Elwood oil field: California Div. Mines Bull. 118, p. 380, 1943.

[125] Tucker, W. Burling, Los Angeles field division—Santa Barbara County: California Min. Bur. Rept. 21, pp. 539-562, 1925.

There are many asphalt and bituminous rock deposits, mainly along the southern coast line and in the Solomon Hills. The principal clay deposits are suitable only for the manufacture of brick and hollow tile products. Only one company has been operating in this industry recently. Extensive deposits of tough gray sandstone suitable for building purposes are located on the south flank of the Santa Ynez Mountains. One property has been active in recent years, producing dimension and flagstone sandstone for building purposes.

Santa Barbara County along with Ventura County contains the principal oil shale deposits in California. These California oil shales, differing from those of other parts of the United States, are oil-saturated diatomaceous shales. Extensive deposits outcrop in the Casmalia Hills and in the Santa Ynez Mountains north of Santa Barbara. Several properties near Casmalia have been operated, and distillation plants have produced from 30 to 35 gallons of crude oil per ton of shale. In recent years one property near Casmalia has been exploited for the production of a light-weight aggregate by burning the oil shale, leaving a tough, light material.

Extensive deposits of diatomaceous earth are located in the coastal foothills from Lompoc to the Santa Ynez River. That near Lompoc is quite large and of very good quality and accounts for by far the largest percentage of the total United States production.

Copper and chromite occur in the southwest slope of the San Raphael Mountains northeast of Los Olivos. Quicksilver occurs in the Santa Ynez Mountains and in the San Raphael Mountains east of Los Olivos. Considerable quicksilver has been produced, some as late as 1946.

Mineral springs occur in the south slope of the Santa Ynez Mountains and have been a source of considerable wealth to the county in the past. The Veronica Springs near Santa Barbara, commercially the most important in the county, are still producing.

Significant Activities During 1947. Santa Barbara County owes its position in the state with regard to mineral production to its output of petroleum and natural gas. During 1947 wells were started in the now-important Cuyama Valley district.

The expansion of the light-weight aggregate industry of California has given added importance to the operations of the Airox Company near Santa Maria in the Casmalia Hills. Using the system developed in 1945, the oil shale once exploited for its oil content is now merely burned in horizontal open beds, each bed containing from 500 to 800 yards of crushed shale. The burning is started by kindling wood fires on the beds and the burning period averages 10 days. The light, tough, burned shale is further crushed and screened. Both fine and coarse material can be used as aggregate. The productive capacity of the operation is 400 yards per 8-hour shift.

The diatomite deposit operated by the Johns-Manville Corporation near Lompoc is generally regarded as the largest and purest deposit in the world.[126] The beds are regarded as belonging to the Monterey formation of the middle and upper Miocene series of marine sediments. The deposit covers several thousand acres and is more than a thousand feet thick; it is, in addition, located in an area of sufficient relief to permit easy

[126] Mulryan, Henry, Geology, mining and processing of diatomite at Lompoc, Santa Barbara County, California: California Div. Mines Rept. 32, pp. 133-136, 1936.

Table 40. Mineral production from Santa Barbara County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[2]
Natural gas	18,070,000 M. cu. ft.	$1,317,000
Natural gasoline and allied products:		
Natural gasoline	36,225,000 gallons	1,861,000
Liquefied petroleum gases	1,542,000 gallons	53,000
Petroleum	22,463,000 barrels	33,221,000
Sand and gravel	198,897 short tons	[1]
Stone	379,890 short tons	[1]
Unapportioned (raw clay, diatomite, sand and gravel, and stone)		4,092,339
Total value		$40,544,339

[1] Value included with "Unapportioned."
[2] U. S. Bureau of the Census not at liberty to publish figure. Value not included in county total.

mining operations. Surface quarrying methods are used. Bricks for insulating purposes are either natural brick cut directly from the deposit or pressed brick from crushed material. Pulverized diatomite is used for filtration, paint pigments, abrasives, gasoline and kerosene clarification, and various admixtures, including some used in cement.

The production of clay, stone, sand and gravel during 1947 were also reported. R.M.S.

SANTA CLARA COUNTY

General Geologic Features. The principal physiographic feature of Santa Clara County is the Santa Clara Valley which traverses the county in a southeastward direction throughout its entire length. From Morgan Hill to the southern border the valley averages 4 miles in width, and drainage is southeastward. North of Morgan Hill the valley is about 2 miles wide at its narrowest point, and drainage is to the northwest. South of San Jose the width of the valley is 15 miles and this width is maintained to the tidal marshes of southern San Francisco Bay. The valley alluvium consists of clays, sands, and gravels of Quaternary age. The Hayward fault striking southeastward nearly coincides with the eastern limit of alluvium in the northern part of the valley. In the southern part a belt of ultrabasic rocks of Jurassic age 1 to 3 miles wide has been mapped west of this fault. The Calaveras fault striking southeastward enters the northern county boundary about 5 miles east of the Hayward fault and converges on the latter east of Morgan Hill. These two faults isolate a wedge-shaped mass of early Quaternary, Tertiary (Miocene), and Cretaceous sediments. East of the Calaveras fault are rocks of the Jurassic Franciscan formation whose outcrops extend beyond the eastern border of the county. The Franciscan consists of sandstone, chert, jasper, schist, serpentine, and basic intrusives. The Franciscan is also the predominant formation west of the Santa Clara Valley, although a strip of Quaternary and Tertiary sediments occupy the valley margin northwest of Los Gatos. In the latter area Franciscan outcrops terminate westward at the San Andreas fault. South of Los Gatos the Franciscan formation is in contact with Tertiary sediments which extend westward to the San Andreas fault. This fault strikes

southeastward and Tertiary sediments outcrop on the west throughout its entire length in the vicinity of Santa Clara County.

Mineral Resources. Brick, building blocks, and clay products are manufactured from extensive deposits of common clay in the vicinity of San Jose and Santa Clara. Chromite occurs in small kidney-shaped bodies and seams in serpentine areas of the Franciscan formation near Red Mountain and southeast of Los Gatos. Copper minerals also occur in the latter area. Good commercial-grade limestone is produced from deposits in the Franciscan formation in the Santa Cruz Mountains which form the western border of the Santa Clara Valley. This limestone has been burned to lime and the deposit at Black Mountain is now used in cement-making by the Permanente Cement Company near Los Altos. Shell lime is dredged at the south end of San Francisco Bay near Alviso. Magnesite has been produced from deposits in serpentine near Red Mountain in the northeastern corner of the county. Manganese oxides associated with chert of the Franciscan formation have also been produced from the Red Mountain area. Mineral springs are found in the mountain ranges on both sides of the Santa Clara Valley. Petroleum and natural gas have been produced in small quantities at Moody Gulch near Alma, and on the Sargent Ranch 7 miles south of Gilroy. The oil at Moody Gulch is 40 to 50° Baumé, and is produced from the San Lorenzo formation (Oligocene) at a depth of about 1,250 feet. The oil at Sargent was 11 to 19° Baumé, and was produced from a sand at the base of the Pliocene at an average depth of about 1,500 feet. The New Almaden mine near San Jose is the locus of the first known occurrence of quicksilver in the United States. In this district cinnabar ore bodies are found along the Franciscan sandstone-serpentine contact. Salt is produced by the solar evaporation of sea water near Alviso at the south end of San Francisco Bay. Sandstone for building purposes has been quarried near Graystone, 9 miles south of San Jose. A small quantity of serpentine is now produced and used in the manufacture of soil conditioners. The production of miscellaneous stone (crushed rock, sand, and gravel) has been an item of importance in this county for many years. Occasional production of granite, gems (jasper), and potash has been recorded.[127]

Significant Activities During 1947. The recovery of cinnabar from the Almaden placers located about a mile southeast of the New Almaden quicksilver mine began in the latter part of 1945 and continued into 1947. In exploring the dumps of burnt ore from the old Scott furnaces a deposit of gravel was discovered overlying the Franciscan sandstone, which contained well-rounded pebbles of 75 percent pure cinnabar as large as 3 inches in diameter. The gravel deposit, about 20 feet deep, consisted of a pay-streak on bedrock, a gradational zone, and an overlying barren layer. The barren gravel was "cast-over" by a P and H dragline with a $\frac{1}{4}$-yard Esco bucket, and the lower gravels were loaded to a truck hauling to a nearby electrically operated washing plant. The latter consisted of a grizzly, a revolving screen, a picking belt for oversize (plus 1 inch) cinnabar, sluice boxes with Hungarian riffles and two Pan American jigs for undersize (minus $\frac{3}{8}$ inch and minus 1 inch). The concentrate was treated in an oil-fired D retort.

[127] Franke, H. A., Mines and mineral resources of Santa Clara County: California Div. Mines Rept. 26, pp. 2-39, 1930.

M. L. Burrell has taken a lease on the Guadalupe quicksilver mine and plans to explore for a new ore body during the coming year.

The Permanente Cement Company completed its post-war expansion program and the productive capacity of the plant reached a new peak of 5½ million barrels of cement annually. The installation of Fuller coolers on each of the four kilns (12 by 463 feet) so increased kiln capacity that it became necessary to install two more 3-foot gyratory crushers to handle the additional clinker. A fifth pump was added under the cement storage silos and a four-compartment, 5,000-barrel packing bin was added to the pack house to handle the increase in bag shipments, which have doubled since 1942. A new 13,000 barrel kiln-feed slurry tank was also installed.

Expanded perlite is now produced commercially at the Campbell plant of the National Perlite Company. Crude perlite from Napa County is ground in a Williams hammer mill and carried on a current of air through a 1½ by 15-foot oil-fired converter, inclined a few degrees from horizontal, where a temperature of about 2,000° F. is attained. Two Schramm diesel compressors each rated at 420 cubic feet per minute, supply the air. On emerging from the converter, the expanded perlite is cooled, sized over baffle plates, and falls to storage bins. It is withdrawn from the latter and bagged in 3-cubic foot containers. The expanded perlite ranges from 3 to 10 pounds per cubic foot in weight.

A moderate quantity of serpentine was produced and fused with phosphate rock at the plant of Permanente Metals Company. The resulting calcium magnesium phosphate (Thermophos) was granulated and sold as a soil conditioner.

Large quantities of crushed rock, and sand and gravel were produced in Santa Clara County. The crushed rock quarries are located near Campbell, Los Altos, Palo Alto, Permanente, and San Jose. The sand and gravel production came from deposits near Coyote, Los Gatos, and San Jose.

Table 41. Mineral production from Santa Clara County during 1947

Product	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)		[1]$1,201,000
Clay, raw	158,206 short tons	[2]
Ferro-alloys	5,278 short tons	[3]
Mercury	586 flasks	49,072
Sand and gravel	352,266 short tons	[2]
Stone	400,080 short tons	462,732
Unapportioned (cement, raw clay, petroleum, sand and gravel, and silica [quartz])		11,469,342
Total value		$11,981,146

[1] According to U. S. Bureau of the Census. Value not included in county total.
[2] Value included with "Unapportioned."
[3] U. S. Bureau of Mines not at liberty to publish figure. Value not included in county and state totals.

Local clays are used for brick-making and blending purposes. Four ceramic plants located near San Jose are manufacturing clay products, brick, and building blocks.

A small quantity of petroleum is produced from one well in Moody Gulch. F.F.D.

SANTA CRUZ COUNTY

General Geologic Features. Castle Rock Ridge of the Santa Cruz Range, trending northwestward, forms the east boundary in the northeastern part of Santa Cruz County. The northeast face of the range is steep and it is bordered on the east by a valley along the line of the San Andreas fault. Castle Rock Ridge has resulted [128] from the compression of massive Vaqueros sandstone of Miocene age into anticlines and synclines west of the San Andreas fault. The Miocene Monterey shale is well exposed and overlies the Vaqueros sandstone. This shale is soft to flinty and mostly diatomaceous; locally there is a bituminous massive sandstone near its base. The gradual seaward descent of the southwest slope of Castle Rock Ridge is interrupted, first by the Butano Ridge anticline, and secondly by Ben Lomond Mountain. The Butano Ridge anticline is a northwestward-trending fold composed chiefly of massive brown and buff Eocene sandstone and the overlying San Lorenzo formation of Oligocene age. The San Lorenzo formation consists of clay shale with intercalated fine-grained sandstone. The Butano fault occupies a valley north of the anticline. A mass of fine- to medium-grained quartz diorite, uplifted and tilted southwestward along the Ben Lomond fault, has resulted in the formation of Ben Lomond Mountain. This mountain has a northeast escarpment and a gentle southwestward slope. West-dipping Miocene sediments flank the quartz diorite in the latter area. Roof pendants of pre-Tertiary schists occur in the quartz diorite. The schist is dark colored, micaceous, and includes minor quantities of crystalline limestone and thin-bedded quartzite. In the southeastern part of the county, lower, middle and upper Pliocene sediments outcrop over a wide area. Quaternary terrace gravels and sand dunes overlie the Pliocene along the coast and along the Pajaro River valley.

Mineral Resources. Records covering the production of minerals in Santa Cruz County date back to 1894, but some bituminous rock, limestone, and gold were produced before that date. The minerals of commercial importance are bituminous rock, clay for cement-making, limestone, sand and gravel, and miscellaneous stone. Other minerals which have been produced in minor amounts are gold, granite, and iron ore. Extensive deposits of bituminous sandstone exist at the base of the diatomaceous Monterey shale extending northwestward from Santa Cruz. Clay and limestone are produced in San Vicente Canyon. The limestone is crystalline, white to blue gray in color, and is associated with pre-Cretaceous rocks. A small tonnage of crushed rock is produced as a by-product of limestone quarry operations. Large deposits of unconsolidated white sand, which includes small amounts of gravel, are associated with the Santa Margarita formation of upper Miocene age in the vicinity of Felton. Gold occurs in black-sand beach deposits near Aptos. Magnetite also occurs in the black sand, and attempts have been made to convert it into sponge iron, ferro-titanium, and magnetite briquettes. Granite has been quarried at Ben Lomond mountain.[129]

Significant Activities During 1947. The Santa Cruz Portland Cement Company is a large mineral producer in this county. The mill,

[128] Branner, J. C., Newsom, J. F., and Arnold, Ralph, U. S. Geol. Survey, Geol. Atlas, Santa Cruz folio (no. 163), 1909.

[129] Hubbard, H. G., Mines and mineral resources of Santa Cruz County: California Div. Mines Rept. 39, pp. 11-52, 1943.

Table 42. Mineral production from Santa Cruz County during 1947

Product	Quantity	Value
Stone	27,280 short tons	$134,127
Unapportioned (asphalt, cement, raw clay, lime, peat, and sand and gravel)		3,082,373
Total value		$3,216,500

located at Davenport, is rated at 10,000 barrels per day. A third Lepol kiln and a Cottrell electrical precipitator have recently been installed. Limestone and clay for the production of cement are produced at the company's quarry in San Vicente Canyon. A distinctive feature is the use of an underground method in mining the limestone. The working plan includes glory holes, transfer raises, bulldozing chambers, chute loading, and adit transportation.

The Pacific Limestone Products Company markets a wide variety of products prepared from crude limestone produced at their quarry about 2 miles west of Santa Cruz. Complex mineral mixes for cattle and livestock are produced in large amounts.

White sand and some gravel, washed and sized, is produced from two large pits near Olympia on Zayante Creek by the Henry J. Kaiser Company, Inc., and the Pacific Coast Aggregates, Inc., respectively. W. Du Bois also produces in this area. Once shot down, the sand is recovered by drag scrapers and conveyor belts, which transport it to the washing plants. The principal products of these plants are sands in the minus $\frac{3}{8}$ inch category. The minus $\frac{1}{8}$ inch is separated on revolving screens into sands as fine as 30 mesh. Most of the final products are the result of blending and are marketed as concrete sands, plaster sands, and asphalt sands.

A small quantity of bituminous rock is produced for use in road dressing. In this material the pore spaces of sandstone are filled with a natural asphalt. F.F.D.

SHASTA COUNTY

General Geologic Features. The eastern half of Shasta County is covered by a succession of plateaus formed chiefly by Pliocene volcanic flows of the Cascade Range. The western half lying within the Klamath Mountain province has a great variety of geologic formations. Extensive deposits of Devonian, Carboniferous, and Triassic shales, sandstones, cherts, and limestones were deposited in a marine environment. Sheets of lava and tuff were intermingled with the sedimentary rocks and covered them in many places. These complex rock formations were compressed, folded, faulted, uplifted, and intruded by masses of granodiorite, quartz diorite, gabbro, and serpentine near the close of the Jurassic period. Erosion and subsidence during the Cretaceous period reduced the Klamath Mountains to a low level, and areas along the southeastern border were beneath the sea for a part of the period. At the close of the Cretaceous, the Klamath Mountains were again uplifted, and subsequent erosion shaped them to their present form. Remnants of Cretaceous sedimentary formations outcrop along the southern and eastern border of these older formations, and large patches of pre-Devonian meta-andesite are exposed in several areas west of Redding.

The geology of Shasta County is shown on maps prepared by Hinds,[130] Anderson and Russell,[131] and by Smith.[132]

Mineral Resources. Amphibole and chrysotile asbestos occur in lenses in serpentine in the northwest corner of Shasta County. Barite occurs in veins in a fine-grained basic rock north of Baird; as a sedimentary deposit in slate east of Castella; and as a gangue mineral associated with sphalerite in the Bully Hill and Ingot districts. Chromite has been mined from lenses in serpentine in the northwestern and southwestern corners of Shasta County. Beds of lignite coal have been found between slate and sandstone of Eocene age in several places east of Oak Run, and at intervals in a northerly direction through the county. Copper deposits occur at intervals in an arc extending from the Greenhorn mine about 3 miles west of Tower House, through Iron Mountain, the Mammoth area, and Bully Hill to Ingot. Chalcopyrite occurs as replacement deposits in rhyolite replacing pyrite, and is in turn replaced by sphalerite in some deposits. Mineralization is probably due to a stock of quartz diorite which intruded the rhyolite and the older sedimentary rocks in the Jurassic period. The copper and zinc minerals in the Bully Hill and Ingot deposits are associated with barite and galena as well as pyrite.

Extensive diatomite beds are found along the Pit River and on Hat Creek. They are fresh-water deposits formed between recent lava flows. Other deposits are found east of Anderson in the southeastern part of the county. Gold is found in the stream gravels, and in quartz veins and stringers in greenstone, granodiorite, quartz diorite, and in slates cut by granodiorite dikes. Iron ore, chiefly magnetite, occurs near the junction of the Pit and McCloud Rivers as a contact deposit between limestone and quartz-augite diorite. Lead is produced from galena associated with copper ores. Galena also occurs with calcite and sphalerite in seams in shales in the Ingot district. Limestone outcrops over extensive areas north and east of Redding. It has been mapped with Devonian, Carboniferous, and Triassic sediments. Manganese oxide and silicate minerals associated with chert and jasper are found filling fissures and cracks in greenstone and schists in eight localities. Both hot and cold mineral springs are found in the volcanic formations of Shasta County. Molybdenite occurs disseminated through an aplitic dike cutting through peridotite northwest of La Moine. Platinum is found associated with the placer gold mined from streams flowing through serpentine formations. Massive pyrite is mined from lenses in rhyolite in the Iron Mountain district. It is associated with the copper and zinc sulphides in the "Shasta Copper Belt," and is a common associate with gold in quartz veins in the western portion of the county. Silver is produced chiefly as a by-product of the copper, zinc, and gold ores, but silver minerals also occur in veins in granodiorite associated with tetrahedrite, galena, pyrite, and sphalerite in the South Fork mining district. Talc deposits occur in lenses in shear zones in meta-andesite in an area north of Schilling. Zinc sulphide occurs as a replacement mineral with chalcopyrite, galena, and pyrite in shear zones in rhyolite and in the adjacent

[130] Hinds, N. E. A., Geologic formations of the Redding-Weaverville district, northern California: California Div. Mines Rept. 29, pp. 77-122, 1933.

[131] Anderson, Charles A., and Russell, R. Dana, Tertiary formations of northern Sacramento Valley, California: California Div. Mines Rept. 35, pp. 219-253, map, 1939.

[132] Smith, J. P., op. cit.

shales. Gold and silver are also recovered from the zinc copper ores. Sand and gravel are produced from pits on the banks of the Sacramento River. The mines and mineral deposits of Shasta County have been described by Averill.[133]

Table 43. Mineral production from Shasta County during 1947

Product	Quantity	Value
Copper	1,396,000 pounds	$293,160
Lead	817 short tons	235,296
Sand and gravel	258,960 short tons	224,273
Zinc	1,707 short tons	413,094
Unapportioned (asbestos, gold, pyrites, silver, and stone)		1,105,403
Total value		$2,271,226

Significant Activities During 1947. Asbestos deposits were developed in the Mears Creek district during the year and some crude amphibole asbestos was produced. Deposits of chrysotile asbestos were also prospected in this district. The production of copper and zinc stopped on June 30 when premium payments ended. Development of additional deposits by diamond-drill exploration was continued however. Sufficient zinc-copper ore carrying both gold and silver was developed at the Afterthought mine near Ingot to justify building a small selective flotation plant. A bridge was built across Little Cow Creek from the highway to the property. The Thurman bucket-line dredge continued operations on Clear Creek a few miles west of Highway 99. The Lincoln Gold Dredging Company remodeled its dragline dredge on Clear Creek near French Gulch. The trommel is now horizontal and is fitted with a spiral screw conveyor, which moves the gravel to the rear and discharges it into the pond about 10 feet beyond the stern. The sand flows into sumps on each side of the boat and is discharged by hydraulic elevators over the coarse gravel at the rear of the boat. This method leaves the tailing pile practically level and with the sand on top. The production of pyrite continued actively at Iron Mountain for shipment to manufacturers of sulphuric acid in the bay area. Sand and gravel plants were active along the Sacramento River producing material for roads and for concrete aggregate. O.E.B.

SIERRA COUNTY

General Geologic Features. Sierra County and Plumas County are adjoining counties at the north end of the Sierra Nevada, and geologic formations extend from one county into the other; hence the description of the general geology of Plumas County given above applies almost equally well to Sierra County.[134] An extensive gold district near Sierra City is associated with a long narrow body of pre-Devonian quartz porphyry or rhyolite striking northwestward. Adjacent rocks are metamorphosed volcanics and sediments of probable Carboniferous age. At the Alleghany district gold ore is found in a series of metamorphosed Car-

[133] Averill, Charles V., Shasta County: California Div. Mines Rept. 35, pp. 108-191, 1939.

[134] See also Averill, C. V., Mineral resources of Plumas County: California Div. Mines Rept. 33, pp. 79-143, illus., map, 1937. . . . Mines and mineral resources of Sierra County: California Div. Mines Rept. 38, pp. 7-67, illus., 1942.

boniferous sediments and volcanics. In places the quartz veins are associated with Jurassic granitic rocks; in others one wall of a vein is ultrabasic igneous rock altered to serpentine. High-grade gold ore is found in this district in erratic occurrence in white quartz. One shipment of 1,935 pounds of ore yielded $116,337 in gold. Between high-grade shoots of this kind, the quartz is likely to be nearly barren. Ferguson and Gannett [135] have considered the possibility that the major fault which is responsible for the fracturing that preceded the deposition of the auriferous veins of the Mother Lode extends northward into the Alleghany district of Sierra County. The Mother Lode has been considered by many persons to end in El Dorado County, but this view seems somewhat arbitrary.

The Eocene river channels are prominent in Sierra County and have been mined on a large scale for gold. The tilting of the Sierra Nevada has raised segments of these great deposits of auriferous gravel so that they are now high on the ridges. Erosion has exposed some of them so that segments may be mined by the hydraulic method and to a limited extent by dredging. Other segments of the channels are deeply buried beneath volcanic tuffs and lavas, and the gold is recovered by underground methods or drift-mining. The gravel in these Eocene channels consists largely of white quartz pebbles. Other channels known as intervolcanic channels contain pebbles and boulders of Tertiary volcanic rocks, and have been mined for gold also, but they are not so productive. In most of them the gold has come from Eocene river-gravels that were eroded by the intervolcanic rivers.

Mineral Resources. Gold has always been the outstanding mineral product of Sierra County, although during the recent war substantial amounts of chrome ore were produced, and a mill was operated for the concentration of chrome ore. Silver accompanies the gold, and small amounts of copper, lead, and platinum have been produced. Prospects near Sierra City contain molybdenite as well as copper. Deposits of iron ore, which have been known for many years to exist in the vicinity of Lake Hawley and Spencer Lakes, have been described in detail recently by Durrell and Proctor.[136] Lenses of limestone are numerous in the Calaveras formation (Carboniferous), and some lime has been produced, but not recently. Local stone is used in highway and county-road construction, but the production is only large enough to fill such local needs.

Significant Activities During 1947. Sixteen to One mine at Alleghany and Brush Creek mine near Goodyears Bar, both lode-gold mines, were producing throughout the year, and development work was done at the Yellow Jacket lode mine near Alleghany. The Oxford mill near Downieville was converted from a gravity mill for concentration of chrome ore to a flotation mill for concentration of gold ore, and concentrate containing gold, silver, lead, arsenic, zinc, and copper was shipped to a smelter. The ore came from the Gold Point mine. Development work at both this mine and the Oxford continued by means of underground workings and diamond drilling. Some production was made at the Ruby mine by drift-mining of gravel. The Ruby contains gold quartz veins as well as auriferous gravel. Concentrate containing gold was shipped from the Oro mine near Downieville. Development work was done at small drift

[135] Ferguson, H. G., and Gannett, R. W., Gold quartz veins of the Alleghany district, California: U. S. Geol. Survey Prof. Paper 172, p. 22, 1932.

[136] Durrell, Cordell, and Proctor, P. D., Iron ore deposits near Lake Hawley and Spencer Lakes, Sierra County, California: California Div. Mines Bull. 129, pp. 166-192, illus., maps, 1948.

Table 44. Mineral production from Sierra County during 1947

Product	Quantity	Value
Gold	13,263 troy ounces	$464,205
Lead	6 short tons	1,728
Silver	2,501 troy ounces	2,263
Total value		$468,196

mines near La Porte. The Colombo mine, a gold-quartz mine near Sierra City, was in production during the year. C.V.A.

SISKIYOU COUNTY

General Geologic Features. The eastern half of Siskiyou County is within the Cascade Range and Modoc Plateau geologic provinces. It is covered with Tertiary and Quaternary volcanic flows, chiefly basalt and andesite, Pleistocene lake beds, and Recent alluvium. Mount Shasta, an extinct volcano, rises to an elevation of 14,162 feet above sea level in the south-central part of the county.

The western half of the county is within the Klamath Mountain province, and includes the wild and rugged Siskiyou, Salmon, Marble, and Scott Mountain ranges in which prominent peaks rise 6,000 to 8,000 feet above sea level. Extensive deposits of Devonian and Carboniferous shale, sandstone, chert, and limestone, show that a large part of the region was beneath the sea during much of the Paleozoic era. Remnants of Upper Cretaceous marine sediments outcrop along the eastern border of the province in the north-central part of the county, and a belt 3 to 4 miles wide outcrops west of Hilt and continues southeastward for about 18 miles. While these sedimentary rocks were forming, volcanoes were active in the region, and lava and tuff are intermingled with the sedimentary rocks and cover them in many places. These complex rock formations were compressed, folded, faulted, uplifted, and intruded by masses of quartz diorite, granodiorite, gabbro, and serpentine near the close of the Jurassic, and most of the mineral deposits were formed at the end of this period. Pre-Cambrian metamorphic rocks, chiefly mica schists, outcrop over large areas along the Klamath River west of Gottville, and along the Salmon River in the Cecilville district. The economic geology of Siskiyou County has been described by Averill [137] and Maxson.[138]

Mineral Resources. Chromite occurs in lenses and disseminated in serpentine in many areas in the western half of Siskiyou County. Lignite and sub-bituminous coal occur between layers of hard sandstone and shale, probably of Eocene age, in Shasta Valley. Many copper prospects occur in the central and northwestern areas of the county. Copper and iron sulphides occur as lenses and in quartz stringers in schists and serpentine. Gold is found in stream and terrace gravels along many streams in western Siskiyou County. Platinum occurs with placer gold in places along the Klamath and Salmon Rivers. Gold-quartz veins and stringers occur in metamorphosed slates, schists, and greenstones of

[137] Averill, C. V., Preliminary report on economic geology of the Shasta quadrangle: California Div. Mines Rept. 27, pp. 3-65, 1931.

[138] Maxson, J. H., Economic geology of portions of Del Norte and Siskiyou Counties, northwesternmost California: California Div. Mines Rept. 29, pp. 123-160, 1933.

pre-Cambrian and Paleozoic ages. They are associated with Jurassic granitic intrusives and diorite dikes. Silver occurs alloyed with gold, and galena is often an associated mineral. Limestone beds occur in the Paleozoic metasediments in the Klamath Mountain areas. It is mined from deposits west of Gazelle. Manganese minerals, chiefly rhodonite but also some oxides and carbonates, are found in lenses and beds in chert and quartzite in the Fort Jones, Sawyers Bar, and Happy Camp districts.

Native quicksilver and cinnabar occur in vugs and fractures in a hornblende schist intruded by granodiorite in the Empire Creek district. Pumice and volcanic ash occur in beds along the north and east borders of the glass flow from Glass Mountain. Sand and gravel are produced from stream gravels and dredge tailing piles. Sandstone was quarried from Cretaceous beds in Shasta Valley east of Yreka. The mines and mineral resources of Siskiyou County have been described by O'Brien.[139]

Table 45. Mineral production from Siskiyou County during 1947

Product	Quantity	Value
Pumice	19,965 short tons	$143,963
Stone	188,970 short tons	149,679
Unapportioned (diatomite, gold, sand and gravel, and silver)		877,329
Total value		$1,170,971

Significant Activities During 1947. Gold dredges were active in Siskiyou County during 1947. The Siskiyou unit of Yuba Consolidated Goldfields was enlarged and resumed operation on the Scott River in September. The French Gulch Gold Dredging Company on Indian Creek, and the Yreka Gold Dredging Company on the Klamath River at Seiad, operated bucket-line dredges throughout the year. The Larsen and Harms dragline dredges on the Klamath River near Happy Camp and on Horse Creek were shut down and moved to British Columbia. Gold Ventures Limited and the Chenowith Brothers dragline dredges operated for a short time on the Klamath River near Seiad and Hamburg. General Dredging Company also operated a dragline dredge on Humbug and Little Humbug Creek for a few months.

Two small hydraulic operations were set up to work benches above the Klamath River. The County mine and Classic Hill property on Indian Creek had short periods of operation.

One of the most interesting events of the year was the development at the Quartz Hill mine, where some very rich gold ore was uncovered with a bulldozer. The mine has been converted to an open-pit operation and a pilot mill was built to treat 1,000 tons per day. Development of the Siskiyou gold quartz vein at the Long Gulch mine continued during the year. A milling plant was erected at the Marath mine near Hornbrook but was shut down after a short operation.

Both agricultural limestone and carbide rock were produced by the Electro Lime and Chemical Corporation at Gazelle. Pumice was mined from deposits in the Glass Mountain area for use as a light-weight aggre-

[139] O'Brien, J. C., Siskiyou County: California Div. Mines Rept. 43, pp. 413-462, 1947.

gate for concrete and in the manufacture of building blocks. Some pumice boulders were sawed into scouring bricks. Sand and gravel were mined from deposits in the vicinity of Mount Shasta, Gazelle, and Yreka.

J.C.O.

SOLANO COUNTY

General Geological Features. Solano County lies north of San Francisco along the western edge of the Sacramento Valley. It is bounded on the west by Napa County, on the north by Yolo County, on the east by the Sacramento River and Sacramento County, and on the south by San Pablo Bay, Carquinez Strait, and Suisun Bay. The county seat is Fairfield; other important cities are Vallejo and Vacaville. Topographically it may be divided into two parts, the flat floor of the Sacramento Valley in the east, which together with the marshes of Suisun and San Pablo Bays in the south make up two-thirds of the area, and a mountainous fringe along the western border. Vaca Valley is a long narrow valley west of Vacaville, which runs parallel to the structure of the Coast Ranges.

The Vaca Mountains consist of a series of Cretaceous sandstone and shale beds flanked on the east by Tertiary sediments. The hills northeast of Vallejo are composed of fault blocks made up largely of Cretaceous and Tertiary sediments and slivers of older rocks. West of Fairfield the sediments are covered by a series of Tertiary tuffs and lavas which is the southeastern extension of a large area of such rocks in Sonoma County. These volcanics also cap the outlying hills near Cordelia and occupy a strip along the high land bordering Suisun Bay as far south as Goodyear Station. Basalt occurs on the hills east of Vaca Valley.

The structure trends northwestward in concordance with that of the Coast Ranges. In the Vaca Mountains the sediments dip more or less uniformly eastward beneath the alluvium of the Sacramento Valley, and neither folding nor faulting is prominent. In the southwest the rocks are folded and dissected by numerous faults, both normal and reverse. The Potrero Hills consist of an anticline of Tertiary rocks whose axis trends approximately eastward.

Mineral Resources. Since the discovery of the Rio Vista gas field in 1936 Solano County has become one of the leading producers of natural gas. This field, which has been described by Frame,[140] surrounds the town of Rio Vista and lies on both sides of the Sacramento River. A small extension to the south is in Contra Costa County. Structurally it consists of a broad, flat, faulted dome slightly elongated in a northwesterly direction. The principal fault, the Midland fault, divides the field into two parts and strikes slightly west of north. Formations encountered range from Recent to Paleocene and Cretaceous. Production is from Eocene formations, which are separated from the upper Miocene by an unconformity. Considerable variation in the thickness of formations and rapid lateral changes in lithology have been encountered.

[140] Frame, R. G., Rio Vista gas field: California oil fields, vol. 30, no. 1, pp. 5-14, 1944.

Most of the gas has been produced from the Emigh zone, which west of the Midland fault is encountered at about 4,275 feet; east of the fault it is only about 3,900 feet deep. Four other gas sands are known, two on each side of the Midland fault. The deepest wells produce from about 5,800 feet.

From 1944-46 other smaller gas fields were discovered beneath the alluvium and marshes of the eastern and southern parts of the county. They include Cache Slough north of Rio Vista, Kirby Hill southeast of Fairfield, Maine Prairie and Millar southeast of Dixon, the east shore of Suisun Bay, the north shore of Honker Bay, and near Winters in the northeast corner of the county. Eocene sands contain all the gas found.

Large quantities of rock suitable for aggregate exist in the Tertiary volcanics and have been worked for many years. Quicksilver was mined northeast of Vallejo intermittently from 1873 to 1936. Other substances which have been prospected for or recovered in the past include magnesite, mineral water, onyx marble, sandstone, fullers earth, lignite, cement rock, and common clay. For many years a cement mill northeast of Fairfield obtained part of its limestone requirements from travertine produced locally.

Significant Activities During 1947. Pipe lines for the commercial delivery of gas were constructed to the Cache Slough, Kirby Hill, Maine Prairie, Millar, and Suisun Bay gas fields. Drilling activity declined at the Rio Vista field, where only four wells were completed and one was drilling at the end of the year. Two producing wells each were completed at the Kirby Hill and Maine Prairie fields and two potential producers in the Solano County part of the Winters area. At the end of the year one well was being drilled at the Kirby Hill field and one being tested at the Suisun Bay field. Two producers have been completed in the Suisun Bay field.

Aggregate is produced from two pits, one near Cordelia, the other a mile north of Goodyear Station. The Cordelia pit, now owned and operated by J. M. Nelson, was originally opened in 1875 to produce paving blocks and has been a producer of aggregate since 1900. The pit is in a flow of olivine basalt which caps a hill composed of tuff. A face about 20 feet high is advanced by blasting, and the broken rock is loaded with a power shovel into trucks for the short run to the primary crusher. The basalt is cut by widely spaced joints, which cause it to break into enormous blocks. At the present time few of them are reduced by secondary blasting. The crushing and screening plant, which is located on the hillside below the level of the pit floor, consists of electrically operated gyratory crushers and trommel screens. Crushed rock, clean sand, and road metal are produced.

The Parish Brothers pit is at Hoyt Siding on state Highway 21 about halfway between Benicia and Cordelia. The operation is at the edge of the marsh on a small outlying hill composed of a series of tuffs and volcanic breccia. A bed of breccia containing hard, tough, angular lava fragments in a matrix of tuff lies on top of the hill and is worked with carry-all scrapers and bulldozers. Material from the pit passes through a jaw crusher and then a portable screening plant containing screens, crushing rolls, and a mechanical classifier. The product is used for the most part in the company's asphalt plant at Benicia.

W.E.V.P.

Table 46. Mineral production from Solano County during 1947

Product	Quantity	Value
Natural gas	65,411,000 Mcf.	$8,155,000
Unapportioned (sand and gravel, and stone)		147,751
Total value		$8,302,751

SONOMA COUNTY

General Geologic Features. The Franciscan formation of Jurassic age outcrops over most of the area of Sonoma County north of Santa Rosa Valley. West of Santa Rosa Valley this formation either outcrops or forms the basement upon which the sediments of the Pliocene Merced formation were deposited.[141] The Franciscan formation consists of massive arkosic sandstone, dark, gray-black, fissile shales, lenses of multicolored chert, ultrabasic igneous rocks altered to serpentine, and metamorphic schists near the contact of the serpentine and the sediments. The schists vary with the locality and may be characterized by any of the following minerals: quartz, albite, epidote, or amphibole. A strip of sandstones, shales, and conglomerates of Upper Cretaceous age outcrop along the coast in the northwestern part of the county. The San Andreas fault separates the Cretaceous from the Franciscan which adjoins it on the east. Marine deposits of Pliocene age outcrop west of Santa Rosa Valley. They consist of clays, arkosic sandstones, conglomerates, and clay shale. A group of Pliocene tuffs, tuff breccias, and basalts, known collectively as the Sonoma volcanics are interfingered with the Pliocene sediments near the south end of Santa Rosa Valley. The Sonoma[142] volcanics extend eastward over a wide area outcropping throughout the range between Santa Rosa and Sonoma Valleys, and in the west half of the range between Sonoma Valley and Napa Valley. Both the Pliocene sediments and the Sonoma volcanics rest unconformably on the Franciscan formation. Pliocene fresh-water deposits consisting of sandy clays, tuffaceous sandy clays, fine-grained sandstones, and conglomerates, conformably overlie the Sonoma volcanics north of Santa Rosa.

Mineral Resources. The recorded production of Sonoma County began in 1873 and the following minerals have been produced commercially in substantial amounts: mineral water, quicksilver, sand and gravel, and miscellaneous stone (crushed rock). Minerals which have been produced in small amounts include: chromite, clay, graphite, magnesite, manganese, sandstone, and tuff. Clay suitable for the manufacture of red brick and tile is located at numerous points throughout the county and clay (kaolin) near Glen Ellen has been used in the manufacture of firebrick. Chromite occurs as kidneys and small lenses in a belt of serpentine striking northwestward through the western part of the county. Graphite is found at a number of localities and a small production was made in 1901 and 1902. Magnesite has been produced from deposits associated

[141] Johnson, F. A., Petaluma region: California Div. Mines Bull. 118, pp. 622-627, 1943.

[142] Dickerson, Roy E., Tertiary and Quaternary history of the Petaluma, Point Reyes, and Santa Rosa quadrangles: California Acad. Sci. Proc., 4th ser., vol. 11, no. 19, pp. 527-601, 1922.

Table 47. Mineral production from Sonoma County during 1947

Product	Quantity	Value
Mercury	4,247 flasks	$355,644
Sand and gravel	584,044 short tons	515,340
Stone	141,370 short tons	[1]
Unapportioned (pumice and stone)		179,067
Total value		$1,050,051

[1] Value included with "Unapportioned."

with serpentine north of Cazadero; additional deposits of magnesite occur in the Cloverdale area. A small production of manganese was reported during World Wars I and II. Mineral paint occurs as red and yellow ocher. Mineral springs in Sonoma County are both numerous and variable in mineral content. The hot waters and steam vents at The Geysers are world famous. The Geysers are located in the heart of the western Mayacmas quicksilver district and the production of quicksilver from this area antedates the statistical record by many years. The ore bodies often lie in altered rock along the Franciscan sandstone-serpentine contacts of a northwestward-trending shear zone. Ore may be either cinnabar or native metal. Nearly all of the quicksilver has been produced by underground methods of mining. A second important quicksilver-producing area is located about 4 miles northeast of Guerneville. Here, ore bodies are also found at the sandstone-serpentine contact. The strike is northwestward and dip is to the northeast. Sand and gravel is mined at numerous points along the Russian River, and crushed rock has been produced near Santa Rosa, Sonoma, and Petaluma.[143]

Significant Activities During 1947. The Mount Jackson-Great Eastern quicksilver mine near Guerneville, operated by the Sonoma Quicksilver Mines Company, is one of the few remaining California quicksilver mines in operation. This property was reopened in 1939 when the old workings were de-watered. This is a sandstone-serpentine contact deposit containing opalite. Cinnabar is the ore mineral and it runs into both walls; the ore averages about 8 pounds per ton. The present workings are on the 690-foot and 775-foot levels. The ground stands well and little timber is required except near entrance points. The shrinkage-stope method of mining is generally used. Stopes 30 by 40 by 100 feet are common. All exploratory work is done with diamond drills. Two Straub Kue-Ken jaw crushers reduce the mine ore to minus 1½-inch furnace feed. Rotary type furnaces are used, one rated at 80 tons and the other at 40 tons per day. Sirocco dust collectors, condensers, redwood tanks, and stacks, constitute the balance of the recovery system. The mine operates 6 days a week on two 8-hour shifts per day. The mill operates on three 8-hour shifts and can handle 125 tons of ore per day. A total of 45 men are employed. The company maintains a camp near Guerneville on the Russian River, 4 miles south of the mine, from which bus transportation is provided to the mine.

In June the Trico Oil & Gas Company brought in an oil well in sec. 30, T. 5 N., R. 6 W., M. D., about 4 miles east of Petaluma. This well produced 25 barrels per day of 20° B gravity oil from Pliocene rocks at

[143] Laizure, C. McK, Sonoma County: California Div. Mines Rept. 22, pp. 327-365, 1926.

a depth of 1,200 feet. The well as placed on the pump using a Parkersburgh unit with a 42-inch stroke at the rate of nine strokes per minute. The unit is run by a 5-horsepower electric motor. It produces through a 2-inch line to a 500-barrel stock tank with a connection for truck loading. The same company produces a small amount of gas from a well about 150 feet south of the oil well.

Crushed rock, sand, and gravel, are produced in substantial quantities in Sonoma County. Much of the sand and gravel is obtained from the beds of streams in the vicinity of Healdsburg. Crushed rock quarries exist at a number of points in the county. One of the most important is located on Highway 101 south of Petaluma. F.F.D.

STANISLAUS COUNTY

General Geologic Features. The northwest-trending Diablo Range, part of the central Coast Ranges of California, forms the western boundary of Stanislaus County. Throughout the summit of this range rocks of the Jurassic Franciscan group are exposed. They consist of arkosic sandstone, argillaceous shale, chert, siliceous shale, conglomerate, and ultra basic igneous rocks altered to serpentine. The Franciscan rocks extend eastward to the Cretaceous contact an average distance of about 6 miles from the summit of the range. The Franciscan formation is differentiated from the overlying eastward-dipping Cretaceous strata by its intense alteration. Shasta sediments (Lower Cretaceous) have been mapped [144] in the southwestern part of the county but marine sediments of the Panoche formation (Upper Cretaceous) rest unconformably on the Franciscan complex in the greater part of the area. In general the Upper Cretaceous consists of Panoche standstone overlain by Moreno shale in a belt about 4 miles wide that trends northwestward. West of Patterson, extending southeastward, the Tejon formation of upper Eocene age overlies the Cretaceous sediments. The Tejon is composed of fine-grained, gray, argillaceous sandstone and interstratified beds of gray clay and brown shale. Overlying the Tejon is a narrow strip of upper Miocene marine sandstone of the San Pablo formation. The central portion of Stanislaus County is covered by Recent alluvium of the northwest-trending San Joaquin Valley. The minimum width of this alluvial cover is 25 miles. On the east side of the San Joaquin Valley the non-marine sandstone, siltstone, conglomerate, andesitic tuff and breccia of the Mehrten formation are exposed in the foothills of the Sierra Nevada. Underlying the Mehrten formation is the westward-dipping Valley Springs formation composed chiefly of fragmental products derived from Miocene rhyolites. The upper Eocene Ione formation is exposed locally near Knights Ferry. Altered Jurassic lavas outcrop along the eastern border of the county and an outcrop of Mariposa slate (Jurassic) has been mapped east of La Grange.

Mineral Resources. The natural resources of Stanislaus County are enumerated in the following list of minerals taken from the production records: clay, chromite, copper, gold, magnesite, manganese, mineral paint, natural gas, platinum, quicksilver, silica, and silver. Chromite occurs in lenses in the Franciscan formation. The ore may contain very little serpentine, or it may be mixed with serpentine and grade into the

[144] Taliaferro, N. L., Geologic history and structure of the central Coast Ranges of California: California Div. Mines Bull. 118, p. 133, 1943.

latter. Pottery clay is produced from the Ione formation near Knights Ferry and local clays for brick-making were produced between 1908 and 1914. A small production of copper was recorded from 1901 to 1904. Gold dredging has a long and profitable history in this county. Dredging activities have been concentrated along the channels of the Stanislaus River east of Oakdale, and along the channels of the Tuolumne River between Waterford and La Grange. Magnesite deposits were located on the east slope of Red Mountain at an early date. The deposits were developed during World War I and some production continued until 1945. The deposits are in the form of magnesite lenses in serpentine. Lenses of manganese ore parallel to the bedding planes of red and green chert are found in the Franciscan formation of Jurassic age. The primary minerals are rhodochrosite and bementite. These deposits were in production during World Wars I and II. Mineral paint (yellow ochre) has been mined intermittently near Knights Ferry. The Vernalis gas field consists of two wells, one of which is in Stanislaus County. This well produces from Cretaceous sands at a depth of about 4,000 feet. Small gas wells at other points in the county supply local consumers. Platinum and silver are produced in small amounts as by-products of gold dredging. The occurrence of quicksilver (cinnabar) in the Franciscan sandstones has been noted and a small production was made during each world war. Crystals, and silica for industrial purposes have been produced from a quartz vein in Del Puerto canyon 12 miles west of Patterson. Sand and gravel is produced in moderate amounts from numerous dry creek beds and old river channels throughout the county. A large deposit of pumicite occurs northwest of Patterson.[145]

Significant Activities During 1947. Numerous barium chemicals are manufactured in the Modesto plant of Barium Products, Ltd., from crude barite shipped in from company-controlled deposits. The barite is burned with carbon in a rotary kiln to yield barium sulphide. The latter is converted into barium carbonate, the base for other barium compounds.

A small amount of pottery-grade clay is produced annually by Lester Raggio near Knights Ferry.

The Cro-Diatomite Company, 202 12th Street, Modesto, is mining a fine-grained white pumicite containing some diatoms from an extensive deposit in the foothills northeast of Newman. This deposit consists of a succession of nearly horizontal beds ranging from half an inch to more than a foot in thickness. Stream dissection has divided the deposit into a number of well-rounded hills that rise about 100 feet above the intervening channels of intermittent streams. Parts of two hills have been stripped of surface soil to a depth of 5 to 10 feet, exposing the deposit. A bulldozer digs and moves the material to a receiving hopper from which it is fed through two Cedar Rapids hammer-mills, each operated by a Waukesha engine. A minus 2-inch product is made and conveyed by belt either to an overhead truck loading bin or to the stock pile. A tunnel loading conveyor belt beneath the stock pile serves three additional overhead truck loading bunkers.

This mineral material is trucked to Patterson where it is processed by the Base Materials Company into the following products: chicken litter, mechanical soil conditioner, fillers, and insecticide carriers. To

[145] Charles A., Mines and mineral resources of Stanislaus County: California Div. Mines Rept. 43, pp. 85-100, 1947.

Table 48. Mineral production from Stanislaus County during 1947

Product	Quantity	Value
Sand and gravel	392,090 short tons	$439,054
Unapportioned (raw clay, gold, natural gas, silver and stone)		673,303
Total value		$1,112,357

meet the specifications required for each product the crude is first dried in a 60-foot rotary kiln, pulverized, and sized.

Small quantities of natural gas, produced from wells near Waterford and Modesto, supply local domestic users. Natural gas produced east of Vernalis is received by the Pacific Gas and Electric Company pipe line.

A large amount of gold, a small amount of silver, and some platinum are produced annually by dredges operating along the channels of the Tuolumne River. La Grange dredge, operating west of the town of La Grange, possesses the longest record of continuous operation in the state. The Tuolumne dredge, about 2 miles south of La Grange, operates in a compact gravel of a Pleistocene river channel, which offers very hard digging. Nearly 90 feet of barren overburden must be removed. Both of these dredges were shut down or restricted during the war but resumed full-schedule operation in 1945. La Grange dredge employs about 30 men and the Tuolumne dredge about 40 men. Moderate quantities of sand and gravel are produced in the vicinity of Crows Landing, Hughson, Modesto, Newman, Oakdale, and Turlock. F.F.D.

SUTTER COUNTY

General Geologic Features. Lying in the south central part of Sacramento Valley, most of Sutter County is nearly flat and about half of it is mantled by Quaternary alluvium. Except for about 4 townships east of Feather River, the county is bounded on three sides by winding streams; Sacramento River is on the west and Feather River on the east. The former turns east to form part of the southern boundary and is joined by the Feather. On the west, the Butte Sink and Sutter Basin are more or less marshy, with lakes and sloughs. The land east of Feather River, and a wedge-shaped area widening northward from the center of the county are covered by Quaternary terrace deposits.

Features of special geologic interest are the Marysville or Sutter Buttes, a roughly circular area of about 10 miles diameter rising from the plain in the northwest. They are the remains of an extinct volcano probably of Miocene age. The highest remnants reach an elevation of 2,000 feet. The region was first mapped and the geology discussed by Waldemar Lindgren and H. W. Turner.[146] This work has since been supplemented by that of Howel Williams [147] and H. R. Johnston.[148] The buttes are divided into three parts: (1) the tuff ring of andesite mud and breccia forming the outer gentle slopes; (2) the upturned sedi-

[146] Lindgren, W., and Turner, H. W., U. S. Geol. Survey Geol. Atlas, Marysville folio (no. 17), 1895.

[147] Williams, Howel, Geology of Marysville Buttes, California: Univ. California Dept. Geol. Sci. Bull. 18, no. 41, March, 1949.

[148] Johnson, H. R., Marysville Buttes gas field: California Div. Mines Bull. 118, pp. 610-615, 1943.

ments exposed when the lava forced its way to the surface; these range in age from Cretaceous to Mio-Pliocene and are a mile or more wide in places; (3) the central core of massive volcanic rocks, where the central crater was opened in pre-existing andesite porphyry. Several rounded plugs of rhyolite occur at intervals around this central core and represent minor craters. In later years this region has become of economic interest as a source of natural gas, which had long been known in seepages.

Mineral Resources. Some of the Eocene gravels exposed by the upheaval of the Marysville Buttes contain pebbles of quartz, granite, serpentine and other rocks familiar in the Sierra Nevada gold region, and were worked for gold in earlier years. In the Ione (Eocene) sediments, clay suitable for pottery occurs and has been produced during the past 10 years in small quantities. Minor prospects of lignite have also been found in the Ione beds, but no deposits of sufficient size to be of commercial value have been noted. Some of the rhyolite plugs in the Buttes contain rock suitable for building stone, which has been used locally. The massive rock of the Buttes craters is also used off and on in small quantities for macadam.

Although very small production of natural gas for local use was reported from 1920 on, serious drilling did not start until 1932 [149] at the Marysville Buttes. A commercial gas field was developed in Upper Cretaceous sediments at depths ranging from 5,365 to 6,882 feet by Buttes Oilfields, Inc. This gas contains 99.68 percent methane, 0.24 percent ethane and has a calorific value of 1,014 British thermal units. A small amount of light amber oil (not currently reported as being produced commercially) occurs with the gas. The natural-gas reserves of this field were reported by the State Oil and Gas Supervisor to be 148,818,028 Mcf. as of July 1, 1947.[150] The proved area is 840 acres.

Significant Activities During 1947. Mineral production in Sutter County during 1947 consisted of raw clay, natural gas, and sand and gravel.

Production of natural gas from Marysville Buttes field was continued by Buttes Oilfields, Inc., at a rate slightly higher than for 1946, when it amounted to 643,011 Mcf. An average of five wells out of a total of seven in the field were in active production. C.A.L.

TEHAMA COUNTY

General Geologic Features. The eastern half of Tehama County is covered by a succession of lava flows ranging from Pliocene basalt to Recent andesite. These were extended from Mount Lassen and other volcanic vents in the Cascade Mountains. Marine sediments of Carboniferous and Cretaceous ages are exposed beneath the lavas in canyons of creeks flowing westward from the mountains. Nonmarine sediments ranging in age from Pliocene to Recent extend some 20 miles east and west from the Sacramento River which flows southward through the middle of the county.

The western half of the county is covered with thick beds of Cretaceous and Jurassic marine sediments. They have been strongly folded and faulted in the Klamath Mountains which form the western border of the county. A serpentine belt about $1\frac{1}{4}$ miles wide strikes northwestward along the eastern slope of the Coast Ranges. It is flanked on the west by

[149] Johnson, H. R., op. cit., p. 610, 1943.
[150] Summary of Operations, California Oil Fields, vol. 33, no. 1.

sandstones, schists, shales, and other sedimentary and metamorphic rocks of Jurassic age. The geology of Tehama County is shown on maps prepared by Anderson and Russell,[151] and Smith.[152]

Mineral Resources. Chromite is found in lenses and bands in the serpentine belt that strikes northwestward along the eastern slope of the Coast Ranges about 35 miles west of Red Bluff. Beds of yellow and white clay from 4 to 160 feet thick are found beneath the surface soil and gravel in the Sacramento River valley. Native copper and chalcopyrite are found associated with pyrite in the serpentine belt west of Red Bluff. Placer gold has been mined from the Sacramento River north of Red Bluff and from Cottonwood Creek along the northwestern border of the county. Some platinum has been recovered from crevices in Beegum Creek. Silver was recovered by refining gold. Small, low-grade, high-silica manganese oxide, manganiferous chert, and manganese carbonate deposits occur in seams and lenses in the Franciscan cherts and metamorphic rocks along the eastern slope of the Coast Ranges. Sulphuretted mineral springs flow from dark shale and sandstone formations overlain by volcanic rocks in widely separated areas. Borax has been recovered from Tuscan Springs about 10 miles northeast of Red Bluff. Natural gas flows from several shallow wells in the vicinity of Flournoy and at Tuscan Springs. A gas zone, 1,070 to 1,504 feet deep, in the Tehama formation northeast of Corning, had an initial maximum daily rate of flow of 17,676,000 cubic feet and a casing pressure of 485 pounds. Sand and gravel are obtained from pits on the banks of the Sacramento River east of Red Bluff, and from the south bank of Thomes Creek east of Richfield. The mines and mineral resources of Tehama County have been described by O'Brien.[153]

Significant Activities During 1947. Sand and gravel were mined from deposits along the Sacramento River at Red Bluff and on Thomes Creek near Richfield. The material was used for roads, concrete aggregate, and in the manufacture of concrete building blocks. J.C.O.

TRINITY COUNTY

General Geologic Features. All but a small portion of Trinity County lies within the Klamath Mountain province and is covered with pre-Cambrian metamorphic rocks, mostly micaceous schists, and metamorphosed Paleozoic sediments, including quartzites, shales, slates, cherts, limestones, and greenstones. These complex rock formations were compressed, folded, faulted, uplifted, and, near the close of the Jurassic period, intruded by masses of diorite, granodiorite, and serpentine. The Mad River separates the Klamath Mountain province from the northern Coast Ranges system, and the southwestern portion of the county is covered with folded and faulted metamorphosed Paleozoic sedimentary rocks, mostly sandstones, shales, and cherts of the Franciscan formations. The geology of Trinity County is shown on maps prepared by Hinds [154] and Smith.[155]

Mineral Resources. Both the amphibole and chrysotile type of asbestos have been mined from small deposits in serpentine in the Carr-

[151] Anderson, C. A., and Russell, R. D., Reconnaissance geologic map of the Tertiary of northern Sacramento Valley: California Div. Mines Rept. 35, pp. 219-253, 1939.
[152] Op. cit.
[153] O'Brien, J. C., Tehama County: California Div. Mines Rept. 42, pp. 183-195, 1946.
[154] Hinds, N. E. A., Geologic formations of the Redding-Weaverville district, northern California: California Div. Mines Rept. 29, pp. 77-122, 1933.
[155] Op. cit.

ville and Altoona districts. Chromite occurs in lenses in serpentine. It has been mined from deposits in the northeastern corner of the county and in an area south of Hayfork. Lignite coal occurs interbedded with shale and fine-grained sandstone of Cretaceous age at Big Bar. It also occurs interbedded with shales and volcanic ash of Eocene age in the Hayfork and Hyampom Valley, and between Redding Creek and Browns Creek southeast of Douglas City. Copper prospects showing copper carbonates, oxides, and some sulphides are found associated with pyrite in serpentine areas in many sections of Trinity County. Production of copper and iron sulphides carrying gold, silver, and some zinc has been made from a deposit in the Island Mountain district in the southwestern corner of the county. The copper mineralization occurs between a soft sandstone hanging wall and a calcareous shale footwall thought to be of the Franciscan group. Gold occurs in stream and terrace gravels and in quartz veins cutting slates, shales, greenstones, and schists near contacts with intrusive masses of Jurassic quartz diorite, granodiorite, and serpentine. It is associated with pyrite and sometimes with galena and calcite. Silver is alloyed with the gold. Platinum is sometimes recovered with the placer gold. Granodiorite has been quarried on Rush Creek, 6 miles east of Weaverville.

Limestone lenses thought to be of Devonian age outcrop in many places along the South Fork of Trinity River from its source to Hoopa Valley. A belt of Carboniferous limestone strikes northwestward along the Hayfork River, disappears north of Hayfork, and appears again in the New River district. Other exposures occur on Browns Mountain southeast of Weaverville, and at the head of Oregon Gulch west of Weaverville. Much of the limestone has been altered to marble. Manganese oxides, carbonates, and silicates are found in 100 localities in Trinity County. They are bedded deposits found with chert in the Franciscan formations. Cold sulfurous mineral springs flow from pre-Cambrian metamorphic rocks along Browns Creek south of Sugarloaf Peak.

Cinnabar occurs in the northeastern section of Trinity County in lenses and veins in an altered granitic rock near the contact with serpentine. Sand and gravel are mined from old placer tailing on East Weaver Creek. The mines and mineral deposits of Trinity County have been described by Averill.[156]

Significant Activities During 1947. The Junction City bucket-line dredge operated on the Trinity River throughout 1947. The Carrville bucket-line dredge found the cemented gravel bedrock too tough to dig profitably and was shut down June 1. Mires and Underseth had their bucket-line dredge operating on Coffee Creek in May and continued throughout the year. The Thompson Divide Mining Company operated two dragline dredges on the Trinity River above Lewiston for several months, and the Placer Exploration Company had their dragline operating below Douglas City for a short time. The Enterprise dragline was moved from Clear Creek in Shasta County to Redding Creek in August and operated there for a few months. Small hydraulic mines were active on Canyon and Weaver Creeks, on bench gravels and old river channels above the Trinity River opposite Junction City and at Salyer. Silver and some platinum were recovered with the placer gold in Trinity

[156] Averill, C. V., Trinity County: California Div. Mines Rept. 37, pp. 8-89, 1941.

Table 49. Mineral production from Trinity County during 1947

Product	Quantity	Value
Gold	13,905 troy ounces	$486,675
Unapportioned (copper, sand and gravel, silver, and stone)		74,880
Total value		$561,555

County. The operator of the Brown Bear mine at Deadwood reopened the old Coon Dog adit and developed a vein of sulphide ore about 6 feet wide. The Fischer Mines Company built a road from Denny to the old Bear Tooth mine and developed a vein of sulfide ore carrying copper and gold. Sand and gravel were produced from tailing-piles on East Weaver Creek. It was used for roads and for a concrete aggregate.

J.C.O.

TULARE COUNTY

General Geologic Features. Tulare County is at the south end of the San Joaquin Valley, extending from the center of that valley eastward to the crest of the Sierra Nevada. The western part of the county for a width of 25 to 30 miles is occupied by valley alluvium, which is known to be underlain by Tertiary sediments because of extensive drilling for oil and gas. The east part of the county is occupied largely by the granitic core of the Sierra Nevada and remnants of the metasediments into which the granitic batholith was intruded. At the Mineral King district, about midway between the edge of the San Joaquin Valley and the crest of the Sierra, is a narrow belt, 15 miles long and 2 to 3 miles wide, of metaquartzite and limestone, thought to be Triassic in age, that extends vertically downward into granite for hundreds of feet. Contact relations show that the granite has intruded the sediments. At Mineral King and farther to the east, the county is very high and rugged, culminating in some high peaks such as Mount Whitney, the highest in the United States, elevation 14,501 feet.

Mineral Resources. The most important mineral resource of Tulare County is gravel, sand, and crushed rock produced near Lindsay and Porterville. The next most important is natural gas produced at the Trico gas field near the northwestern corner of the county. Several horizons in the San Joaquin clays, a Plio-Pleistocene formation, are productive. Substantial amounts of tungsten ore are produced in the mountains east of Dinuba, Porterville, and Lindsay. One of the districts has been described by Jenkins.[157] Scheelite and quartz are found in contact-metamorphic deposits with garnet and epidote, which have replaced limestone. Minor amounts of scheelite have been found in both granite and marble. The county was formerly a large producer of magnesite from bodies of serpentinized peridotite associated with granitic rocks and thin belts of limestone in the foothills east of Exeter, Lindsay, and Porterville. Gold has been produced in the White River district 15 miles southeast of Porterville. At Mineral King deposits of ore carrying gold, silver, copper, lead, and zinc are found associated with the intrusive contact of the granite and Triassic sediments. Other mineral resources of

[157] Jenkins, William O., Tungsten deposits northeast of Visalia, California: California Div. Mines Rept. 39, pp. 169-182, 1943.

Table 50. Mineral production from Tulare County during 1947

Product	Quantity	Value
Stone	92,040 short tons	$132,457
Unapportioned (natural gas, sand and gravel, and tungsten concentrates)		1,368,094
Total value		$1,500,551

the county include barite, chromite, clay for brick and tile, diatomite, granite, gypsum, feldspar, limestone, manganese, and talc.

Significant Activities During 1947. The most important recent development in Tulare County is the extension of the Trico gas field. Recent drilling has developed an extension of this field to the northwest to almost double the proved acreage available for production. A new gas zone has been discovered 800 feet deeper than the old one, and this new zone is expected to produce as much as the old one, thus adding greatly to the reserves of this field. Production of tungsten ore continues at some of the higher-grade mines, and a small tonnage of amphibole asbestos has been produced near White River. The asbestos mill was being remodeled in May 1948. C.V.A.

TUOLUMNE COUNTY

General Geologic Features. Tuolumne County extends from the foothills on the east side of San Joaquin Valley, at an elevation of less than 1000 feet, to the summit of the Sierra Nevada. The mountainous southeast part, about a quarter of the total area, is in Yosemite National Park. From this region the Tuolumne River supplies water through the Hetch Hetchy project to San Francisco. The North Fork of the Stanislaus River forms the north boundary with Calaveras County, and with the Middle and South Forks of the same stream have carved deep canyons which receive the water from dozens of smaller streams draining the northern part of the county. The southern section is in the drainage basin of Tuolumne River. Drainage is in general toward the southwest. The topographic picture is that of a plateau dissected by the modern streams in the western part but merging on the east into a rugged mountainous region, with many peaks from 9,000 to 11,000 feet high and much evidence of late Pleistocene glaciation.

The western half of the county is of principal interest to the miner because of the gold deposits found there. With the exception of comparatively small areas of Eocene auriferous gravel and later flows of volcanic breccia, mud, and massive lava that filled older canyons, there are none of the younger geologic formations found here. If ever present, they were swept away by the long-continued erosion which has cut deeply enough into the older rocks to expose, in many places, the upper parts of granitic rocks. These rocks of granitic texture grade more toward the basic end of the rock series in the western part of the county. They intrude Jurassic or Carboniferous rocks and are probably outliers of the main Sierra Nevada batholith exposed in the eastern part of the county. The largest and most important of these areas is shown to be connected with the main mass to the northeast and has a width of about 7 miles in the vicinity of

the town of Sonora. Many gold-bearing quartz veins have been found along its eastern border near Soulsbyville and southward, and gold deposits nearby on the west but outside of the granodiorite itself may be genetically connected with it. A small area of granodiorite at Big Oak Flat also contains numerous quartz veins carrying pockety gold deposits.

At the western boundary of the county and for several miles eastward, meta-augite porphyry occurs. It has been derived from basic volcanic breccia and tuffs and has been placed by earlier geologists as earlier than late Cretaceous but on the last stage geologic map [158] is shown as Jurassic basic meta-igneous rock. East of it appears the westernmost area of the Upper Jurassic Mariposa slate, an altered marine deposit. These slate beds strike northwest. This particular Mariposa area has been of minor economic importance. In one place it has been intruded by granodiorite, resulting in contact metamorphism and permitting the geologic dating of at least this particular intrusion as post-Jurassic. East of this belt of slate, the porphyrite and amphibolite schist derived from it extend as far as Woods Creek and Moccasin Creek, where another belt of Mariposa slate occurs. This traverses the county with a northwesterly strike and steep northeasterly dip. It is important here because it is the locus, for several miles in this county and southeastward into Mariposa County, of the Mother Lode gold belt. At intervals along the east side of this slate belt, large dikes or sills of ultrabasic igneous rocks now altered to serpentine occur. The largest such intrusive is in the central metavolcanic area, having a width of 4 miles between Chinese Camp and Crimea House and extending 14 miles from the western county line southeastward. These serpentine bodies have yielded some chromite, magnesite, and copper.

The Mother Lode slate and serpentine are flanked on the east also by a continuous strip of amphibolite schist in which a few small syenite dikes occur. This amphibolite schist nearly everywhere separates the Mariposa slate from the Carboniferous altered sediments on the east. The Carboniferous (Mississippian) rocks occupy a width of 15 miles, extending across the county with a northwest strike. The only interruptions to their continuity are the intrusions of granodiorite already mentioned, the largest of which is a peninsula extending southwest from the main batholith almost across the entire width of the older rocks. These Carboniferous rocks are a complex containing clay slate, quartzite, chert, mica schist, and limestone altered mostly to marble, as well as numerous small dikes. All of these rocks have been compressed and closely folded by tremendous pressure prior to or during the batholithic intrusion at the end of the Jurassic. They strike almost uniformly northwestward and dip steeply northeast, at right angles to the direction of pressure. Dark-colored dikes have in places been rendered so schistose as to closely resemble slate. This pressure also determined the dip and strike of schistosity of all the Jurassic rocks previously mentioned. Cretaceous and later erosion removed a great depth of the Carboniferous rocks to expose the granodiorite. The Carboniferous in this county is notable economically for its great deposits of marble, ranging from nearly pure dolomite to high-calcium limestone. Gold is also widely distributed in quartz veins and pockets. The phenomenal richness of many such gold deposits broken up during the long period of erosion of the Carbonifer-

[158] Jenkins, O. P., op. cit. (1938).

ous rocks is attested by the richness of the gold placers worked in early days in the Columbia basin and the large pockets found even now in these rocks in the Sonora region.

The eastern part of the county, about two-thirds of its total area, consists of the plutonic rocks of the Sierra Nevada batholith, with several areas of Miocene andesite and minor flows of Tertiary volcanics. Gold quartz mining has been followed successfully along the borders of the granodiorite to an elevation of about 4,000 feet.

The geology of the western part of the county was mapped by H. W. Turner and F. L. Ransome.[159] Nomenclature of geologic formations in this paper has been changed to conform with the Division of Mines Geologic map of California, 1938, by Olaf P. Jenkins and others.

Mineral Resources. Since pioneer days, gold mining has been the most important mineral industry in Tuolumne County. Production from the shallow placers on limestone bedrock in the Columbia region is claimed to have been greater than from any similar area. The placers there and near Sonora received gold from nearby pocket deposits, and many large nuggets were found. Farther west, shallow placers were formed from erosion of the upper parts of the Mother Lode veins. Although the gold of the Columbia and nearby placers was presumably concentrated in ancient channels which in turn were partly exposed by erosion and made accessible for surface mining, the production from drift mining on remaining buried sections of such channels was of little importance. Placer mining in recent years was confined to operation of draglines on some of the streams.

In Tuolumne County the Mother Lode veins traverse slate, amphibolite schist, and serpentine, and several have been important producers, although development has not reached the depths attained in some other counties. The East Belt gold mines are in the Carboniferous rocks extending 15 miles east of the Mother Lode, and around the borders of granitic intrusives in these rocks. Some of the largest East Belt producers such as the Black Oak, Soulsby, and Confidence mines had productions of several million dollars each.

The pocket veins of Sonora, Bald Mountain, Shaws Flat, and nearby districts, which fed so much gold into the shallow placers, have continued to yield substantially up to the present time. Their gold is generally in beautiful crystal or leaf form, much in demand for specimens.

Next in importance to gold are marble and limestone. More building marble has been quarried in the Columbia district than from the rest of the state, but that now being produced is used for other purposes. This marble is generally magnesian, but immense quantities of high-calcium limestone as well as grades approaching dolomite are available.

Prospects of short-fiber chrysotile asbestos have been noted in some of the serpentine bodies previously mentioned. Chromite has been mined at intervals since early days from the same serpentine, when the price warranted. The most important producer has been the McCormick mine west of Jamestown. Some of the serpentine areas near Chinese Station have also yielded magnesite. Copper ore has been produced from a few small properties in the meta-augite andesite in the southwestern part of the county, and some copper has also been saved from concentrate

[159] Turner, H. W., and Ransome, F. L., U. S. Geol. Survey Geol. Atlas, Sonora folio (no. 41), 1895. . . . Big Trees folio (no. 51), 1891-96.

Table 51. Mineral production from Tuolumne County during 1947

Product	Quantity	Value
Copper	12,000 pounds	$2,520
Gold	4,232 troy ounces	148,120
Silver	2,015 troy ounces	1,824
Stone	43,330 short tons	252,189
Unapportioned (lime, sand and gravel, and talc)		496,414
Total value		$901,067

from a few gold-quartz mines. Graphite was produced and shipped abroad in the sixties from deposits near Columbia and Sonora. Slate from the Mariposa beds near Hetch Hetchy Junction has been mined and crushed for granules on asphalt roofing for 10 years prior to 1940. Some sales of soapstone were also made from near Jamestown. Scheelite prospects are found in areas of granitic rock near Confidence, Crocker Station, and elsewhere; small sales were reported from one property. The production of by-product silver from gold ores has been substantial, and some by-product lead has also come from gold ores, especially from those of the East Belt. A few prospects of molybdenite have been noted. Miscellaneous stone is produced for local use. Granite of fine quality has been quarried east of Sonora. A deposit of diatomite in the extreme western part of the county is undeveloped.

Significant Activities During 1947. Eagle Shawmut mine was the only important gold-quartz producer on the Mother Lode in 1947. Miller and Clemson operated the mine until October 1947, when high and increasing costs made it unprofitable to continue. All equipment not needed at their other mine outside the state was offered for sale. Gross and Street mines on Jackass Hill near Tuttletown were prospected by Hawood Corporation (Cecil R. Haden and C. E. Wood) and a promising showing was found by diamond drilling and later opened by crosscut and drifts, but milling of ore did not begin until 1948. The same people unwatered the Alabama mine west of Jamestown and did some prospecting underground but made no production. Some work was done on East Belt mines including the North Star, Buchanan, Providence, and Lucky Strike at Arastraville and Independent. Jones and Waggoner at the Lucky Strike had some good ore ready to mill late in the year. At the Hidden Treasure mine 3 miles north of Columbia Keenan and Gibson mined pocket ore. A pocket was also found by Stobaugh, Coats, and Ray at the Fidelity mine, near Five-Mile Creek, and a large pocket came from the Carlin-McCutcheon mine. In general, however, gold mining was quiet as prospective operators awaited more favorable conditions. Most important among those planning work is Harvard Gold Mining Company which completed an extensive diamond-drilling program at the Harvard mine on the Mother Lode near Jamestown some time ago and anticipates large-scale operation when costs of labor and supplies will permit. The total gold production of the county was 4,232 fine ounces valued at $148,120. By-products from gold mines were 2,015 fine ounces of silver and 12,000 pounds of copper.

Limestone, lime, and dolomite were produced by U. S. Lime Products Company from a deposit near their plant 1 mile south of Sonora and

from a quarry formerly operated by Columbia Marble Company north of Columbia. During 1947 Sonora Marble Aggregates Company built a plant at Shaws Flat where the principal products are terrazzo aggregates and aggregate for built-up roofing. Hard magnesian limestone and marble found near the plant are used. Limestone and its products exceeded gold during the year in value of output. C.A.L.

VENTURA COUNTY

General Geologic Features. Ventura County, with an area of 1,878 square miles, is one of the coastal counties. The northern part of the county, which lies partially within the southern limits of the Coast Ranges geomorphic province, is in sharp contrast to the southern part which is in the Transverse Range province. The rugged, mountainous northern section can be considered as the meeting place of the San Raphael, Santa Ynez, and the San Emigdio Mountains. The latter, extending to the northwest, form a portion of the connection between the Coast Ranges and the Sierra Nevada. The peaks of this northern part range from 6,000 feet to nearly 9,000 feet in elevation and form one of the roughest and most inaccessible regions in California. The Cuyama River has its source here on the northern slope of Pine Mountain.

The southern portion of the county contains several eastward-trending ranges, mostly anticlinal in structure and of low elevation and short length. The extreme westward tip of the Santa Monica Mountains extends into the southeastern corner of the county. The important drainage of the county is contained in the three principal valleys of this section, which are the Ojai, drained by the Ventura River, the Santa Clara, drained by the Santa Clara River, and the Simi and Las Posas, drained by Calegnas Creek. These three valley areas also contain the principal oil fields of the county.

The basement complex crystalline rocks are a series of metamorphic pre-Jurassic rocks and the invading granite which is probably of the same age as that of the Sierra Nevada.[160] The sedimentary rocks of the county, which form the greater percentage, range from Upper Cretaceous to Recent. In the vicinity of Ventura, in the Ventura Basin, probably the thickest marine Pleistocene-Pliocene section in the world occurs, its total thickness being 18,000 to 19,000 feet.[161] In the Pliocene epoch alone over 15,000 feet of sediment was deposited, which is a thickness for that epoch alone without parallel in any other region. The igneous extrusives, exposed mainly in the southern part of the county, are practically all Miocene. A section of these volcanics, the Conejo volcanics, is unique in that a small oil field is located therein. This series is composed of basalt flows and pyroclastics with minor basalt and andesite dikes. Olivine basalt underlies the series which overlies the Topango formation (upper lower Miocene). This olivine basalt is considered to be the reservoir rock of the Conejo field.[162]

[160] Kew, W. S. W., Geology and oil resources of a part of Los Angeles and Ventura Counties, Calif.; U. S. Geol. Survey Bull. 753, 1924.

[161] Stewart, R. E., Rincon oil field: California Div. Mines Bull. 118, pp. 387-390, 1943.

[162] May, J. C., Conejo oil field: California Div. Mines Bull. 118, p. 424, 1943.

Geology of parts of the county has been described by Fairbanks [163] and Kew.[164]

Mineral Resources. Ventura County has produced asphalt and bituminous rock, borax, clay, gypsum, limestone, mineral water, mineral paint, molding sand, sandstone, flagstone, crushed rock, sand and gravel, gold, silver, lead, petroleum and natural gas.[165]

The borax deposits, inactive because of relative inaccessibility, are fairly important reserves. They are located in a narrow belt along the eastern slope of Mount Pinos in the northeast corner of the county. Three larger mines were developed in this district, the Columbus, Frazier, and Russel. The clay deposits of the county are mostly of low grade, suitable for brick and hollow tile or for drilling mud. The latter is still being produced. Gypsum has been produced from South Mountain and Oak Ridge, and recent production has come from Cuyama Valley.

Limestone and agricultural lime are produced from the Santa Susana area. Deposits in Matilija Canyon, north of Ojai, have also been exploited. A deposit of molding sand, best suited for gray iron, aluminum, and brass castings [166] is located within the Ventura city limits. Some sandstone was quarried in Grimes Canyon in 1945 and Sespe Canyon sandstone has been quarried in past years. Grimes Canyon has also been the source of a decorative rock resembling volcanic material. It was originally siliceous shale of the Modelo formation (Miocene) which had been ignited and fused to brilliant reddish and black masses. The crushed rock, sand and gravel industry, along the Ventura and Santa Clara River beds, has long been of importance to the county.

The gold deposits are in the mountainous region of the northeastern part of the county, including Mount Frazier on the north and McDonald Peak on the south. In this Piru district the gold occurs in veins in the crystalline rocks which make up the mountains and in the gravels of the Piru drainage basin. Considerable gold was produced prior to 1880, some being shipped as early as 1842. Recorded production through 1941 totals $43,666.

Petroleum and natural gas, the mainstay of Ventura County's mineral production, have come from 10 principal fields.

Significant Activities During 1947. Ventura County owes its position in the state with respect to mineral production to its output of petroleum and natural gas.

The expanded building industry in the state has kept some of the sand and gravel plants active along the Santa Clara River. The principal producers during 1947 were the Saticoy Rock Company near Saticoy and the Montalvo Rock Company at Montalvo.

A light-weight aggregate from shale at Ventura is produced by the Rocklite Company. The fine, uniform shale from an extensive deposit is crushed, screened to several sizes and each size is fired separately in rotary kilns to approximately 2,000°. This takes it to a state of incipient fusion, and when discharged from the kiln, the pieces are well rounded and possess an almost glazed surface sealing in the porosity. The material

[163] Fairbanks, H. W., Geology of northern Ventura, Santa Barbara, San Luis Obispo, Monterey, and San Benito Counties: California Min. Bur. Rept. 12, pp. 493-526, 1894.

[164] Kew, W. S. W., op. cit. (1924).

[165] Tucker, W. B., and Sampson, R. J., Ventura County: California Div. Mines Rept. 28, pp. 247-277, 1932.

[166] Wright, Lauren A., California foundry sands: California Jour. Mines and Geology, vol. 44, pp. 37-72, 1948.

Table 52. Mineral production from Ventura County during 1947

Product	Quantity	Value
Natural gas	46,140,000 M cu. ft.	$4,392,000
Natural gasoline and allied products:		
Natural gasoline	110,140,000 gallons	7,923,000
Liquified petroleum gases	40,962,000 gallons	831,000
Petroleum	26,858,000 barrels	48,750,000
Sand and gravel	676,173 short tons	[1]
Unapportioned (raw clay, sand and gravel, and stone)		618,862
Total value		$62,514,862

[1] Value included with "Unapportioned."

is excellent for an aggregate where high strength is required. The capacity of the plant was expanded late in 1947.

The Western Lime Products Company has been the only limestone producer in the county in the past few years. A deposit of shell limestone north of Santa Susana on Rancho Simi is being quarried, and the production goes for poultry and cattle feed and for agricultural lime.

There was some renewal of activity in gold mining in the county. One property on Piru Creek near the Los Angeles County line was being prepared for a hydraulic operation. R.M.S.

YOLO COUNTY

General Geologic Features. Yolo County fronts on Sacramento River on the east for 42 miles. The eastern two-thirds of the county is covered by Quaternary alluvium that forms the fertile, nearly level surface of Sacramento Valley. West of Zamora and Winters, continental Pliocene deposits extend for several miles across the county from north to south. These are succeeded on the west by a belt of Upper Cretaceous marine sediments which lie along the western county line until the northwest corner of the county is reached. There, the Lower Cretaceous and Knoxville beds outcrop over an area about equal to one township, with small exposures of intrusive serpentine and extrusive Tertiary volcanics.

The valley portion adjacent to Sacramento River is only from 10 to 30 feet above sea-level and is protected by levees and by the Yolo by-pass, provided to draw off water from the river at extreme high-water stages. To the west, the elevation of the land increases gradually to 60 feet at Woodland, 18 miles west of Sacramento, and to 150 feet at Madison. The hills of the east slope of the Coast Ranges occupy the western and extreme northwestern part of the county.

The geologic features of principal interest are anticlines—particularly those partly outlined in drilling for natural gas in the Fairfield Knolls in secs. 29, 32, T. 9 N., R. 1 E., and those in the Rumsey Hills extending northwest from Capay past Rumsey and into Colusa County. At Fairfield Knolls, dry natural gas was found in the middle Eocene Capay (Ione) at a depth of 3,675 feet and production has resulted. Only two wells, not enough to outline the size of the field, have been drilled. The Rumsey Hills anticline is over 30 miles long. Here Cretaceous beds are in part covered on the north end and on both flanks of the anticline by the upper Pliocene Tehama formation. Seepages of natural gas were

Table 53. Mineral production from Yolo County during 1947

Product	Quantity	Value
Sand and gravel	167,650 short tons	$70,276
Unapportioned (mercury, natural gas, and stone)		191,152
Total value		$261,428

noted years ago in this region. Numerous wells have been drilled during the past 50 years along this anticline to depths varying from 400 to 6,763 feet, and several showings of natural gas, some with flowing salt water, were found. So far no commercial production of either natural gas or petroleum has resulted. Two gas wells were brought in 12 miles northwest of Woodland in the Dunnigan Hills in 1946. The first, in sec. 22, T. 11 N. R. 1 W., struck gas between 2,400 and 2,620 feet in depth in a formation tentatively classified as Meganos (lower Eocene). A smaller gas flow was obtained in the second well in sec. 28, T. 11 N., R. 1 W. Neither of these wells had been put on production at the end of 1947. A third well in sec. 15, T. 11 N., R. 1 W., was drilled to 2,800 feet and abandoned. In sec. 28, T. 9 N., R. 1 W., a well was drilled to 5,486 feet and abandoned. This is about midway between Winters and Madison. In the southeast end of the county in sec. 10, T. 6 N., R. 3 E., a wildcat well was abandoned after reaching a depth of 4,912 feet. Results of later drilling are not yet available.

Mineral Resources. Probably the first mining in the county was for gold along Cache and Putah Creeks. From 1933-38 a few thousand dollars in gold was produced from the vicinity of Putah Creek. Platinum-group metals have been reported from near that stream west of Winters in association with gold. Quicksilver production was first recorded in 1873. Bluish-gray sandstone was quarried near Putah Creek west of Winters between 1890 and 1908 and a volcanic tuff found 5 miles west of that town was used locally in a few early-day buildings. Common bricks were made in three brickyards at Woodland, one at Winters, and one at Capay, many years ago. Narrow seams of coal have been noticed in Cache Creek Canyon, at the head of Cottonwood Creek, in Coal Gulch 7 miles west of Winters and elsewhere in the northwestern part of the county. No commercial production has been recorded, though some of the coal may have been used locally. Limestone and manganese oxide prospects 3 miles south of Cadenassa have been reported. Several mineral springs are known, but the water has been used only locally in a small way. Most of them are sulfur springs.

In value of output, quicksilver production has been most important. The mines are in the northwestern corner of the county, south of west from Rumsey. The January or Harrison mine and the Reed mine were producers from 1873-80. From 1914-19 and from 1938-43, one or both of them reported production, but from 1943-46 inclusive the Reed was the only active property; even there, work has been suspended on account of the low price of quicksilver.

Significant Activities During 1947. Sand, gravel, and crushed rock are produced from Cache Creek and from Putah Creek by operators from Yolo, Esparto, and Woodland. The annual output ordinarily is moderate,

amounting to only a few hundred thousand tons, most of it sand and gravel. Owing to present highway construction activity, there will be an increase in this item in 1948.

Standard Oil Company of California has two producing gas wells that have been connected up to the Rio Vista gas line for some time. They are the Corcoran well in SE¼ sec. 29, T. 9 N., R. 1 E., and the Hooper well in NE¼ sec. 32, T. 9 N., R. 1 E., in the Fairfield Knolls area.

C.A.L.

YUBA COUNTY

Geologic Features. Yuba County lies between Butte and Nevada Counties and centers slightly north of the latitude of Point Arena. The western half of the county lies in the Great Valley and the eastern half in the mountains of the Sierra Nevada. The gently dipping sediments of the Great Valley are largely masked by Recent river deposits and soil mantle. Consequently, they are exposed in Yuba County only on the eastern outskirts of the Great Valley where they lap up onto the tilted basement rocks of the Sierra Nevada. Passing eastward into the Sierras, the bedrock is exposed as ancient tuff, flow, and agglomeratic volcanics in various stages of metamorphism from massive metavolcanic greenstones to amphibole and mica schists. These have been intruded by granitic rocks ranging in composition from gabbro to granodiorite. Small local intrusions of pyroxenite, serpentine, etc., pre-date the granitic intrusions but do not approach the latter in size. Bedrock metasediments belong chiefly to the Calaveras formation and outcrop only in the northeast corner of the county. They range in composition from quartzite through slate to limestone, and are Upper Paleozoic in age. Folded structures of the Bedrock series tend to have a northwestward trend but the structures are disrupted by major batholithic intrusions and by thrust faults. Fault strikes tend to roughly parallel the regional structures and, in general, are results of the same period of diastrophism. Few if any of these have anything approaching the magnitude of the Mother Lode thrust system.

Small patches of Tertiary andesitic lava lie as remnants on the eroded bedrock surface in the northeastern part of the county. Many of these are underlain by or adjacent to Eocene auriferous gravels, the remnants of old stream channels which the lavas have protected from obliteration by erosion. The gold-bearing gravels which are so important to Yuba County economically are in part these Eocene channel remnants and in part reworked river deposits of Pleistocene and Recent age. By far the largest output of gold at the present time is coming from Quaternary gravels at the edge of the Sacramento Valley. Deposits resulting directly from deposition of gold during early Tertiary erosion, derived from lodes exposed during Cretaceous time, are mined on a smaller scale.

Mineral Resources. Auriferous gravels are still the chief sources of mineral wealth in Yuba County. Enormous tonnages are mined annually by huge dredges and, in addition to the gold recovered, are valuable as sources of stone for aggregate and road material.

Silver is produced in considerable quantities as a by-product in gold refining, silver being present in almost all gold in alloy form. Platinum and platinum-group metals such as iridium and osmium are sometimes recovered as by-products from gravitational concentration of gold in auriferous gravels. Considerable reserves of lode gold still remain in

Yuba County but very few are being exploited because of high operating costs.

Small, irregular production of brick clay, pottery clay, copper, and mineral water has been reported in past years but none of these commodities were marketed from Yuba County during 1947. Clay reserves are large but scattered; copper reserves are probably small. Scattered deposits of asbestos and talc are known to occur in Yuba County but they are small and remote from transportation centers. Deposits of limestone of good quality for processed lime and portland cement occur along the North Fork of the Yuba River south of Camptonville but they are too remotely situated to be of value at the present time.

Mining Activities During 1947. Production of mineral materials in Yuba County during 1947 consisted of gold, crude platinum metals, sand and gravel, and silver.

The most important operation in Yuba County in the mineral industries is that of the Yuba Consolidated Gold Fields in the vicinity of Hammonton. This company runs five large dredges in the Yuba River basin, the second largest mining venture in the state during 1947. The dredges are electrically operated, the largest having 135 buckets of 18 cubic feet capacity and the smallest having 87 buckets of similar size.

The Fresno Mining Company operated the Greater Forty-Niner suction dredge in Strawberry Valley, and reported a fairly large gold recovery. A small amount of gold was recovered from hand placers at several points along the Yuba River. The Slapjack mine at Challenge and the Hinton property at Dobbins both reported small gold production during the year. These are lode mines. The Empire Star Mines Company, Ltd., also produced from its lode mine in Browns Valley.

Several sand and gravel companies operated along the Yuba River. The largest was the Yuba River Sand and Gravel Company which has been steadily expanding its output of rock products.

Slate has been produced near Rough and Ready for flagstone and kindred purposes at various times the past few years but no steady production has been reported. O.E.B.

Table 54. Mineral production from Yuba County during 1947

Product	Quantity	Value
Gold	65,788 troy ounces	$2,302,580
Silver	3,767 troy ounces	3,409
Unapportioned (crude platinum metals and sand and gravel		253,143
Total value		$2,559,132

PART 3

DIRECTORY OF MINERAL PRODUCERS, DEALERS, AND COMMERCIAL LABORATORIES

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DIRECTORY OF PRODUCERS OF METALLIC AND NONMETALLIC MINERALS IN CALIFORNIA DURING 1947

(Producers of natural gas and petroleum may be found in the Summary of Operations, California Oil Fields, July-Dec. 1947, vol. 33, no. 2, of the State Division of Oil and Gas.)

ASBESTOS (TREMOLITE)

Operator	Address	Location of mine
Placer County		
Joe Delmue & H. Zimdars	Forest Hill	Iowa Hill
Shasta County		
Powhatan Mining Co.	Woodlawn, Baltimore, Md.	Castella
Stock Deposit, Homer E. Finn	133 Katherine St., Salinas	Hazel Creek
Sylvester, Ray	Box 1435, Weed	Castella

BARITE

Operator	Address	Location of mine
Mariposa County		
Baroid Sales Division, National Lead Co.	830 Ducommun St., Los Angeles	El Portal
Plumas County		
Barium Products Ltd.	Newark	Almanor

BENTONITE (FULLERS EARTH)

Operator	Address	Location of pit
Inyo County		
Sierra Talc Company	5509 Randolph, Los Angeles 22	Olancha
Kern County		
D. P. Covert	309 Bank of America Bldg., Glendale	Boron
San Benito County		
San Benito Bentonite Co.	Prune Ridge Rd., Santa Clara	Paicines
San Bernardino County		
Baroid Sales Division, National Lead Co.	830 Ducommun St., Los Angeles	Hector
Pacific Bentonite Mine, Louis Martinez	Box 374, Red Mountain	Red Mountain

BITUMINOUS ROCK

Operator	Address	Location of mine
Santa Cruz County		
Calrock Asphalt Co.	232 Montgomery St., San Francisco	Majors

BORATES

Operator	Address	Location of property
Inyo County		
Pittsburgh Plate Glass Co., Columbia Chemical Division	Bartlett	Bartlett
United States Borax Co.	510 W. 6th St., Los Angeles 14	Shoshone
Kern County		
Pacific Coast Borax Co.	510 W. 6th St., Los Angeles 14	Boron
San Bernardino County		
American Potash and Chemical Corp.	3030 W. Sixth St., Los Angeles 54	Trona
West End Chemical Co.	Latham Square Bldg., Oakland 12	Westend

BROMINE

Operator	Address	Location of property
Alameda County		
Westvaco Chlorine Prod. Corp. (changed to Westvaco Chemical Corp. in 1948)	405 Lexington Ave., New York 17, N. Y.	Newark
San Bernardino County		
American Potash and Chemical Co.	3030 W. Sixth St., Los Angeles 54	Trona

CALCIUM CHLORIDE

Operator	Address	Location of mine
San Bernardino County		
California Rock Salt Co.	2436 Hunter St., Los Angeles 21	Amboy
Desert Properties Co., Frank Thomas, Receiver	374 Court St., Rm. 11, San Bernardino	Amboy
Hill Brothers Chemical Co.	2159 Bay St., Los Angeles 21	Amboy
National Chloride Co.	P.O. Box 18, Amboy	Amboy

CARBON DIOXIDE GAS

Operator	Address	Location of wells
Imperial County		
Cardox Western, Inc.	748 Washington Blvd., Los Angeles 21	Niland
Mendocino County		
Caldri Ice Corp.	1168 Battery St., San Francisco	Hopland
L. J. Gibson	Ukiah	Ukiah

CEMENT

Operator	Address	Location of mill
Calaveras County		
Calaveras Cement Co.	315 Montgomery St., San Francisco 6	San Andreas
Kern County		
Monolith Portland Cement Co.	215 W. 7th St., Los Angeles 14	Monolith
Los Angeles County		
Blue Diamond Corp.	1650 S. Alameda St., Los Angeles 54	Los Angeles
Riverside County		
Riverside Cement Co.	621 S. Hope St., Los Angeles 14	Crestmore
San Benito County		
Pacific Portland Cement Co.	417 Montgomery St., San Francisco 6	San Juan Bautista
San Bernardino County		
California Portland Cement Co.	601 W. Fifth St., Los Angeles 13	Colton
Riverside Cement Co.	621 S. Hope St., Los Angeles 14	Oro Grande
Southwestern Portland Cement Co.	503 Roosevelt Bldg., Los Angeles 14	Victorville
San Mateo County		
Pacific Portland Cement Co.	417 Montgomery St., San Francisco 6	Redwood City
Santa Clara County		
Permanente Cement Co.	Permanente	Permanente
Santa Cruz County		
Santa Cruz Portland Cement Co.	324 Crocker Bldg., San Francisco 4	Davenport

CHROMITE

Mine	Operator	Address	Location of mine
Butte County			
Lambert	Helmke, Thomas, & Janssen	320 Market St., San Francisco	Magalia
Del Norte County			
Tyson (French Hill)	Sam J. Wilson	Patricks Creek Tavern via Crescent City	Crescent City

CLAY

(Including producers of crude clay; and manufacturers of brick, tile, porcelain, etc.)

Operator	Remarks	Address	Location of plant or pit
Alameda County			
California Pottery Co.	a, c	Niles	Niles
N. Clark & Sons Division, Pacific Clay Products Co.	a, b	Box 145, Sta. A, Los Angeles	Alameda
Gladding-McBean & Co.	c, b	2901 Los Feliz Blvd., Los Angeles	Altamont, Livermore
Interlocking Tile Co.	a	Niles	Niles
Henry J. Kaiser Co.	c	1924 Broadway, Oakland	Radum
Kraftile Co.	a, b, c	Niles	Niles
M. & S. Tile Co.	a, c	Decoto	Decoto
Merritt Supply Co.	a	P.O. Box 1, Sta. A., Berkeley	Berkeley
Tesla Clay & Sand Co.	c, f	220 Montgomery St., San Francisco	Tesla
Amador County			
Cal. Mineral Products Co., Ione Clay and Sand Pit	c, f	Kohl Bldg., San Francisco	Ione
N. Clark & Sons Division, Pacific Clay Products Co.	c	401 Pacific Ave., Alameda	Ione
Gladding McBean & Co.	c	2901 Los Feliz Blvd., Los Angeles	Ione
Western Refractories Co.	b, c	Russ Bldg., San Francisco	Ione
Calaveras County			
California Pottery Co.	c	Niles	Valley Springs
Contra Costa County			
American Radiator & Standard Sanitary Mfg. Co., H. W. Creeger, Mgr.	a	Box W, Richmond	Richmond
California Art Tile Corp'n.	a	Box 1116, Richmond	Richmond
Gladding, McBean & Co.	b	2901 Los Feliz Blvd., Los Angeles	Pittsburg
Port Costa Brick Works, C. G. Berg, Pres.	b	Sixth and Berry Sts., San Francisco	Port Costa
Technical Porcelain & Chinaware Co.	a	Manila & Kearny Sts., El Cerrito	El Cerrito
United Materials & Richmond Brick Co., Ltd.	a, b	Box 7, Richmond	Richmond

Fresno County			
Craycroft Brick Co.	a, b, c	Belmont & Lafayette Sts., Fresno	Fresno
Humboldt County			
Hindley Clay Products	a, b, c	3121 Essex St., Eureka	Cutten
Inyo County			
Sierra Talc Co.	e	5509 Randolph Ave., Los Angeles	Olancha
Kern County			
American Minerals Co.	c	5601 S. Boyle, Los Angeles	Cantil
Bakersfield Sandstone Brick Co.	b	Bakersfield	Bakersfield
D. P. Covert	e	309 Bank of America Bldg., Glendale	
Kernco Materials Co.	d	1916 Radiance Dr., Bakersfield	
King Lumber Co.	b	Box 1559, Bakersfield	Bakersfield
Macco Construction Co., dba Antelope Materials Co.	d	815 Paramount Blvd., Clearwater	Rosamond
Los Angeles County			
American Container Co., Inc.	a	3132 Washington Blvd., Los Angeles 23	Los Angeles
Angulo Tile Co.	a, c	Reseda	Reseda
Atkinson Brick Co.	b	13633 Central Ave., Los Angeles	Los Angeles
J. A. Baucrs Pottery Co.	a	415 W. Ave. 33, Los Angeles	Los Angeles
J. Booth	a	1775 Stanford Ave., Santa Monica	Santa Monica
Builders Brick Co., Ltd.	b	17602 S. Western Ave., Moneta	Moneta & Compton
B. W. Tile Co.	a	14600 S. Western Ave., Gardena	Gardena
Coast Brick Co	b	P.O. Box 326, Moneta	Moneta
H. F. Coors Co., Inc.	a	Inglewood	Inglewood
Davidson Brick Co.	b	4701 Floral Dr., Los Angeles	Los Angeles
General Refractories Co.	b	3363 Fruitland Rd., Los Angeles	Los Angeles
Gladding McBean & Co., Tropico, L. A. & S. M. Plants	a, b, c	2901 Los Feliz Blvd., Los Angeles	Tropico, Los Angeles, Santa Monica, Hermosa Beach and Vernon
Higgins Brick & Tile Works	b	P.O. Box 1125, Sta. A, Gardena	Moneta
Italian Terra Cotta Co.	a	1149 Mission Rd., Los Angeles	Los Angeles
Lynn Brick Co.	b	Normandie & Pacific Coast Hwy., Harbor City	Harbor City
Pacific Clay Products	a, b, c	Box 145, Sta. A, Los Angeles	Los Angeles and Los Nietos
Pacific Tile & Porcelain Co.	a	P.O. Box 638, Hynes	Hynes
Pomona Brick Co., S. Bernard Strona	b	Pomona	Pomona
Pomona Tile Mfg. Co.	a	629 N. La Brea Ave., Los Angeles	Pomona
St. Louis Fire Brick & Insulation Co.	b	3050 E. Slauson St., Huntington Park	Huntington Park
Simons Brick Co., Walter R. Simons	b	1195 S. Boyle Ave., Los Angeles	Los Angeles
Southwest Brick Co.	b	17601 S. Western Ave., Los Angeles	Los Angeles
San Valle Tile Kilns	a	1258 N. Highland Ave., Los Angeles	Reseda
Valley Brick & Supply Co.	b	6151 Kester Ave., Van Nuys	Van Nuys
Vernon Potteries	a	2300 E. 52d St., Los Angeles	Vernon

CLAY—Continued

(Including producers of crude clay; and manufacturers of brick, tile, porcelain, etc.)

Operator	Remarks	Address	Location of plant or pit
Marin County			
McNear Brick Co.	a, c	McNear Point, San Rafael	McNear
Orange County			
El Toro Clay Co., I. P. Arnold	c, f	7655 W. 2d St., Downey, Los Angeles	El Toro
La Bolsa Tile Co.	a, c	R.F.D. 1, Box 174, Huntington Beach	Smeltzer
Placer County			
Gladding, McBean & Co.	a, b, c	2801 Los Feliz Blvd., Los Angeles	Lincoln
Lincoln Clay Products Co.	c	P O. Box 367, Lincoln	Lincoln
Riverside County			
Alberhill Coal & Clay Co.	c	Box 4267, Village St., Los Angeles	Alberhill
Los Angeles Brick Co.	a, b, c	1078 Mission Rd., Los Angeles	Alberhill
Pacific Clay Products	c	Box 145, Sta. A, Los Angeles	Corona
Temescal Clay Co.	c	2569 Clarendon Ave., Huntington Park	Temescal
Sacramento County			
Cannon & Co.	a, b, c	Box 802, Sacramento	Ben Ali
H. C. Muddox, Jessie E. Muddox, Owner	a	30th and L Sts., Sacramento	Sacramento
Panama Pottery Co.	a	R.F.D. 4, Box 1478, 24th St. Rd., Sacramento	Sacramento
Sacramento Brick Co.	b	1300 Front St., Sacramento	Sacramento
San Benito County			
San Benito Bentonite Co.	e	Rt. 1, Box 237, Santa Clara	Paicines
San Bernardino County			
Baroid Sales Div., National Lead Co.	d, e	830 Ducommun St., Los Angeles	Hector
Desert Talc & Clay Co.	c	Pomona	Barstow
Hancock Brick Yard, C. P. Hancock & Son	b	Box 421, Riverside	Highgrove
Gladding, McBean & Co.	c	2901 Los Feliz Blvd., Los Angeles	Goff
Marter Mining Co.	c	530 W. 6th St., Los Angeles 14	Bryman
Pacific Bentonite Mine, Louis Martinez	e	Box 374, Red Mountain	Red Mountain
Southern California Minerals Co., W. K. Skeoch	c	320 S. Mission Rd., Los Angeles	Goff
San Diego County			
Union Brick Co., J. W. Rice	b	P. O. Box 356, North San Diego	Rose Canyon

San Joaquin County			
Laurel Potteries	a	McKinley Ave., Stockton	Stockton
Pacific Clay Products Co.	a, c	Box 145, Station A, Los Angeles	Stockton
San Joaquin Brick Co.	b	33 S. El Dorado St., Stockton	Stockton
Stockton Brick & Tile Co.	a	McKinley Ave., Stockton	Stockton
San Luis Obispo County			
San Luis Brick Works	d	San Luis Obispo	San Luis Obispo
Santa Barbara County			
McNall Building Materials	a, b	208 N. Salsipuedes, Santa Barbara	Santa Barbara
Santa Clara County			
Garden City Pottery	a	560 N. 6th St., San Jose	San Jose
Gladding Bros. Mfg. Co.	a, b, c	S. 3rd and Keyes Sts., San Jose	San Jose
Myers Ceramic Pottery, F. Hinz	a	Box 97, Santa Clara	Santa Clara
Remillard-Dandini Co.	b	569 3rd St., Oakland	San Jose
Stanislaus County			
Lester Raggio	c	Knights Ferry	Knights Ferry
Sutter County			
Gladding, McBean & Co.	c	2901 Los Feliz Blvd., Los Angeles	Nicolaus
Ventura County			
Shell Oil Co., Dent Clay Pit	d	Shell Bldg., San Francisco	Ventura

a. Clay products. b. Brick and hollow building-tile. c. Crude clay. d. Oil-well drilling-mud. e. Filtering clay. f. Fire sand.

COAL

Operator	Address	Location of mine
Amador County		
American Lignite Products Co.	Ione	Ione
Mendocino County		
Lee Giersch & Gus Creason	Dos Rios	Dos Rios
Trinity County		
Trinity Coal Co., Wm. A. Mumford	Weaverville	Douglas City

COPPER

Mine	Operator	Address	Location of mine
Amador County			
Newton	Pacific Mining Co.	1022 Crocker Bldg., San Francisco	Ione
Calaveras County			
Penn	Shawmut Copper Mine Co.	Chinese Camp	Camp Seco
El Dorado County			
Pioneer-Lilyama	Pioneer Lilyama Mines	Placerville	Placerville
Inyo County			
Darwin & Shoshone groups	Anaconda Copper Mining Co.	25 Broadway, New York, N. Y.	Darwin & Tecopa
Defense	Foreman & Skinner	1354 2nd Ave., Salt Lake City, Utah	Keeler
Lane Eagle	L. D. Foreman	1354 2nd Ave., Salt Lake City, Utah	Keeler
Pine Creek	U. S. Vanadium Corp.	30 E. 42nd St., New York, N. Y.	Bishop
Santa Rosa	Santa Rosa Mining Co. & Louis Warnken, Jr.	Keeler	Keeler
Shoshone group (Columbia No. 2)	Finley Co. (taken over by Anaconda Copper Mining Co. June 1, 1947)	Tecopa	Tecopa
Mono County			
Benton	L. D. Foreman	1354 2nd Ave., Salt Lake City, Utah	Benton
Plumas County			
Walker	Plumas Mining Co.	Portola	Walkermine
San Bernardino County			
Mohawk	Mohawk Mines, Inc.	Nipton	Nipton
Roosevelt	Donald F. Love	Ludlow	Ludlow
Shasta County			
Hornet-Richmond	The Mountain Copper Co., Ltd.	216 Pine St., San Francisco	Matheson
Kennett Flue Dust (Mammoth)	C. E. Wuench & C. T. McNeil	300 Montgomery St., San Francisco	Kennett
Tuolumne County			
Eagle Shawmut	Eagle Shawmut Mine	Chinese Camp	Chinese Camp

DIATOMITE (DIATOMACEOUS EARTH)

Operator	Address	Location of mine or quarry
Inyo County		
Blue Star Mines, Ltd.	810 So. Spring St., Los Angeles 14	Zurich
Los Angeles County		
Great Lakes Carbon Corp., Dicalite Division	756 S. Broadway, Los Angeles 14	San Pedro
Modoc County		
H. W. Free	Tionesta	Tionesta
Santa Barbara County		
Johns-Manville Products Corp.	22 E. 40th St., New York 16, N. Y.	Lompoc
H. M. Johnson	P. O. Box 34, Solvang	Solvang

DOLOMITE

Operator	Address	Location of quarry
Inyo County		
Inyo Marble Co., D. H. Dunn, Pres.	726 E. 29th St., Los Angeles	Keeler
Monterey County		
Permanente Metals Corp.	P. O. Box 1531, Salinas	Natividad
San Benito County		
Westvaco Chemical Corp.	Newark	Hollister
San Bernardino County		
Marter Mining Co.	530 W. 6th St., Los Angeles 14	Thorn
Tuolumne County		
U. S. Lime Products Corp.	1840 E. 25th St., Los Angeles 25	Sonora

FELDSPAR

Operator	Address	Location of mine
Madera County		
Almyra S. Anderson	1405 N. Fresno St., Fresno 4	Friant

GEMS AND JEWELERS' MATERIALS

Operator	Address	Variety
San Diego County		
Geo. Ashley	Pala	Kunzite
Pala Chief Mine, Margaret S. Moore & M. Wear	Box 33, Pala	Kunzite

GOLD

(Principal producers from a total of 420)

Mine	Type of Mine*	Operator	Address	Location of mine
Amador County				
Belden	a	Belden Amador Mines, Inc.	Pine Grove	Pine Grove
Burke, Tom Ranch	h	Mountain Gold Dredge	Sutter Creek	Sutter Creek
Kennedy and others	a	Kennedy Mining & Milling Co.	519 California St., San Francisco	Martell
Lilly	h	Earnest L. Lilly	Plymouth	Plymouth
Peterson	a	Russell A. Donnelly	Jackson	Pine Grove
Butte County				
Boat No. 1	h	Hoosier Gulch Placers	Oroville	Oroville
Butte Unit	e	Yuba Consolidated Gold Fields	351 California St., San Francisco	Hammonton
Dredge No. 5	e	Lancha Plana Gold Dredging Co.	Lockford	Chico
Drescher Ranch	h	Placer Exploration Co.	Chico	Chico
Kister Dredge	e	Gold Hill Dredging Co.	311 California St., San Francisco	Oroville
Calaveras County				
Mountain King	a	Mountain King Mill & Mine	410 Thorne Ave., Fresno	Copperopolis
Penn	s	Shawmut Copper Mine Co.	Chinese Camp	Campo Seco
Royal	a	Allen W. Doe, et al	Copperopolis	Copperopolis

El Dorado County				
Baldwin & Burke pty.	h	Knight Placer Mining Co.	Georgetown	Georgetown
Barkeley lease	h	Greenhorn Dredging Co.	Placerville	Placerville
Ostenrider Ranch	h	Marion G. Hennes & Knight Placer Co.	Georgetown	Garden Valley
Fresno County				
Rockfield	t	Pacific Coast Aggregates, Inc.	400 Alabama St., San Francisco	Friant
Inyo County				
Darwin and Shoshone groups (Columbia No. 2)	m	Anaconda Copper Mining Co.	25 Broadway, New York	Darwin & Tecopa
Shoshone Group (Columbia No. 2)	m	Finley Co. (taken over by Anaconda Copper Mining Co. June 1, 1947)	Tecopa	Tecopa
Kern County				
Tropico and others	a	Burton Brothers	Rosamond	Rosamond
Mariposa County				
Wm. Jenkins, W. E. Porath, pty., and Upper Bear Creek Placers	h	James H. Henry	706 Burton Bldg., Stockton	Kinsey and Bear Valley
Mount Gaines	a	Mount Gaines Mining Co.	Hornitos	Hornitos
Merced County				
Merced Dredge No. 1	e	Merced Dredging Co.	1805 Mills Tower, San Francisco	La Grange
Snelling Gold Dredge	e	Snelling Gold Dredging Co.	Snelling	Snelling
Nevada County				
Ancho & Erie groups	a	Ancho Erie Mining Co.	Nevada City	Washington
Empire Star Group	a	Empire Star Mines Co., Ltd.	Grass Valley	Grass Valley
Idaho-Maryland & New Brunswick	a	Idaho-Maryland Mines Corp.	368 Russ Bldg., San Francisco	Grass Valley
Relief Hill	g	Western Gold, Inc.	942 Russ Bldg., San Francisco	Nevada City
Spring Hill	a	Spring Hill Corp.	1911 Mills Tower, San Francisco	Grass Valley
Placer County				
Doty Ravine	k	Schwartz & Mitchell	Roseville	Roseville
Horseshoe Bar	h	Horseshoe Bar Mines	Foresthill	Foresthill
Mary Len	a	Mary Len Mine	Newcastle	Newcastle
Plumas County				
Walker	j	Plumas Mining Co.	Portola	Walkermine

* Key to symbols is at end of table.

GOLD—Continued

(Principal producers from a total of 420)

Mine	Type of Mine*	Operator	Address	Location of mine
Sacramento County				
Capital Dredge	e	Capital Dredging Co.	351 California St., San Francisco	Fair Oaks
Consumnes Dredge	e	Consumnes Gold Dredging Co.	405 California St., San Francisco	Folsom
Dredge No. 4	e	Lancha Plana Gold Dredging Co.	Natoma	Folsom
Dredge No. 4	e	Thurman & Wright	235 Montgomery St., San Francisco	Sloughouse
General Dredge	h	General Dredging Co.	Natoma	Natoma
Natomas Dredges	e	Natomas Co.	P. O. Box 1197, Sacramento	Natoma
Stanton & Ryan	h	Mountain Gold Dredging Co.	Sutter Creek	Sloughouse
San Bernardino County				
Kelly	b	F. W. Royer	Randsburg	Randsburg
Roosevelt	a	Donald F. Love	Ludlow	Ludlow
Spud Patch placer	r, k	Sureease Mining Co.	1820 D St., Sacramento	Atolia
San Joaquin County				
Lower Comanche and Upper Comanche dredge	e	Gold Hill Dredging Co.	311 California St., San Francisco	Camanche
Shasta County				
Buckeye	h	Roy S. Olson	1178 Walnut Ave., Redding	Redding
Clark-Jansen pty.	h	Lincoln Gold Dredging Co.	Lincoln	French Gulch
Kennett Flue Dust (Mammoth)	u	C. E. Wuench & C. T. McNeil	300 Mongomery St., San Francisco	Kennett
Thurman dredge	e	Thurman Gold Dredging Co.	235 Montgomery St., San Francisco	Redding
Sierra County				
Brush Creek	a	Alfred L. Merritt	453 Scenic Ave., Piedmont	Downieville
Original 16 to 1	a	Original Sixteen to One Mines	1611 Russ Bldg., San Francisco	Alleghany
Siskiyou County				
Indian Creek Placer	e	French Gulch Dredging Co.	307 Russ Bldg., San Francisco	Indian Creek
Portuguese	e	Gold Ventures, Ltd.	Seiad Valley	Seiad Valley
Quartz Hill	a	Quartz Hill Syndicate	Scott Bar	Scott Bar
Scandia and Scandia No. 3	h	Scandia Mine	Rt. 4, Box 2220, Sacramento	Horse Creek & Happy Camp
Siskiyou unit	e	Yuba Consolidated Gold Fields	351 California St., San Francisco	Callahan
Yreka Gold dredge	e	Yreka Gold Dredging Co.	220 Montgomery St., San Francisco	Seiad Valley

Stanislaus County				
La Grange dredge No. 4	e	La Grange Gold Dredging Co.	1805 Mills Tower, San Francisco	La Grange
Tuolumne Gold dredge	e	Tuolumne Gold Dredging Co.	1 Sansome St., San Francisco	La Grange
Trinity County				
Carr Ranch	e	Carrville Gold Co.	351 California St., San Francisco	Trinity Center
Junction City dredge	e	Junction City Mining Co.	Junction City	Junction City
Long Bar	h	Thomson Divide Mining Co.	Box 525, Redding	Lewiston
Lorenz & Fout pty.	h	Placer Exploration Co.	Box 1214, Chico	Douglas City
Mires & Underseth	e	Roy Mires & Carl Underseth	Redding	Trinity Center
Tuolumne County				
Eagle Shawmut	a	Eagle Shawmut Mine	Chinese Camp	Chinese Camp
Fidelity	d	Wayne Stabaugh	Columbia	Columbia
Hidden Treasure	d	Harry Gibson & H. C. Keenan	Columbia	Columbia
Yuba County				
Yuba unit	e	Yuba Consolidated Gold Fields	351 California St., San Francisco	Hammonton

* a. Lode gold mine. b. Gold-silver mine. c. Tailings dump. d. Pocket. e. Dredge (bucketline). g. Hydraulic mine. h. Dragline operation. j. Copper mine. k. Power shovel or dryland dredge. m. Lead mine. o. Zinc mine. r. Tungsten mine. s. Copper-zinc mine. t. Gravel plant. u. Smelter slag and flue dust. v. Silver mine. w. Silver-lead mine. x. Zinc-lead mine. y. Pyrites mine.

GRANITE

Operator	Produet*	Address	Location of quarry
Fresno County			
Superior-Academy Granite Co.	a	Clovis	Academy
Lassen County			
Greig Quarry, J. B. Wagender	a	Susanville	Susanville
Los Angeles County			
H. A. Jones, et al	a	215 W. Green St., Pasadena	Saugus
Nevada County			
Netz Monumental Works	a	502 Factory St., Nevada City	Nevada City
Placer County			
Union Granite Co.	a	Roeklin	Rocklin
Rictor Wickman	a	Roeklin	Rocklin
San Bernardino County			
Texas Quarries, Inc.	a	Box 605, Victorville	Victorville
San Diego County			
California Cut Stone & Granite Works	a	Railroad Ave. at Magnolia, South San Francisco	Vista
Crystal Blaek Quarry, John Stridsburg	a	Box 115, Escondido	Spooks Canyon
Lakeside Silver Gray Granite Co.	a	Lakeside	Lakeside
Alvin I. Lodge	a	1480 S. Lorena St., Los Angeles	Santee
National Quarries	a	Rt. 2, Box 185, Escondido	Escondido & Fall Brook
Pacifie Cut Stone & Granite Co.	a	414 S. Marengo Ave., Alhambra	Escondido
Southern California Granite Co.	a	3845 Imperial Ave., San Diego 2	Foster
Sonoma County			
Roy J. Johns	b, e	P. O. Box 93, Boyes Springs	Glen Ellen

* Granite used in building and monumental stone. b. Tuff used as building stone. c. Volcanic rock used as flagstone and building stone.

GYPSUM

Operator	Address	Location of quarry
Alameda County		
Westvaco Chlorine Prod. Corp. (Output not included in production figures as gypsum is by-product of chemical process using minerals already included in state total.)	405 Lexington Ave., New York, N. Y.	Newark
Fresno County		
Agricultural Mineral & Fertilizer Co., A. D. Sousa	P. O. Box 832, Los Banos	Los Banos
Imperial County		
U. S. Gypsum Co.	300 W. Adams St., Chicago 6, Ill.	Plaster City
Kern County		
Carriso Gypsum Mine, Fannin & Hatley	Wasco	Wasco
Crystal Gypsum Co.	P. O. Box 823, Oildale	Oildale
H. M. Holloway	Box 310, Lost Hills	Lost Hills
McKittrick Agricultural Gypsum Co.	McKittrick	McKittrick
Pacific Gypsum Co., W. D. Fowler	P. O. Box 563, Bakersfield	Conner
C. E. Vanderford Gypsum Mine	Shandon	Shandon
Western Gypsum Co.	Wasco	McKittrick
Kings County		
H. M. Holloway	Box 310, Lost Hills	Avenal
Riverside County		
American Gypsum Co.	1140 H St., Fresno	Inca Siding
United States Gypsum Co.	300 W. Adams St , Chicago 6, Ill.	Midland
Ventura County		
Monolith Portland Cement Co.	215 W. 7th St., Los Angeles 14	Cuyama Valley

IODINE

Operator	Address	Mine
Los Angeles County		
Deepwater Chemical Co., Ltd.	Box 588, Compton	Compton
The Dow Chemical Co.	Midland, Michigan	Long Beach, Venice, and Seal Beach

IRON

Mine	Operator	Address	Location of mine
Riverside County			
Eagle Mountain	Kaiser Co., Inc., Iron and Steel Div.	P. O. Box 217, Fontana	Indio
San Bernardino County			
Cave Canyon	Mineral Materials Co.	1145 Westminster Ave., Alhambra	Baker
Vulcan	Kaiser Co., Inc., Iron and Steel Div.	P. O. Box 217, Fontana	Kelso

Mine	Operator	Address	Location of mine
Calaveras County			
Penn	Shawmut Copper Mine Co.	Chinese Camp	Campo Seco
Inyo County			
Black Canyon	Black Canyon Mine	Los Angeles	Big Pine
Cerro-Gordo	L. D. Foreman & Enterprise Mining Co.	1354 2nd Ave., Salt Lake City, Utah	Cerro-Gordo
Darwin and Shoshone group (Columbia No. 2)	Anaconda Copper Mining Co.	25 Broadway, New York, N. Y.	Darwin and Tecopa
Empire	Dopplemayer & Crandell	Keeler	Keeler
Gold Bottom-Ophir	Damon & Damon	1612 Oregon St., Redding	Trona
Lane Eagle, Modoe, & Wonder	L. D. Foreman	1354 2nd Ave., Salt Lake City, Utah	Keeler
Lead King	George Lippincott	Box 1811, Santa Ana	Cerro-Gordo
Santa Rosa	Santa Rosa Mining Co. & Louis Warnken, Jr.	Keeler	Keeler
Shoshone group (Columbia No. 2)	Finley Co. (taken over by Anaconda Copper Mining Co. June 1, 1947)	Tecopa	Tecopa
Silver Spoon	Theo. Peterson	Cartago	Keeler
Surprise	Foss & Osborne	441 Oxford Ave., Hawthorne	Panamint Spgs.
Ubehebe	Ubehebe Mines, Inc.	356 S. Spring St., Los Angeles	Owenyo
Mono County			
Benton	L. D. Foreman	1354 2nd Ave., Salt Lake City, Utah	Benton
San Bernardino County			
Blue Buzzard	B. V. Whitney	Cima	Cima
Carbonate King	Tibbets, Slattery & DeWitt	Nipton	Nipton
Carbonate King Zinc	J. Q. Little	Nipton	Nipton
Mohawk	Mohawk Mines, Inc.	Nipton	Nipton
War Eagle	Finley Co.	Dunn	Bagdad
Shasta County			
Hornet-Richmond	The Mountain Copper Co., Ltd.	216 Pine St., San Francisco	Matheson
Kennett Flue Dust (Mammoth)	C. E. Wuench & C. T. McNeil	300 Montgomery St., San Francisco	Kennett

LIME AND LIMESTONE

Operator	Product*	Address	Location of quarry
Alameda County			
Westvaco Chlorine Prod.	a, d	405 Lexington Ave., New York, N. Y.	Newark
El Dorado County			
Auburn Lime Products Co.	a, b	Box 231, Auburn	Auburn
California Rock & Gravel Co.	b	1800 Hobart Bldg., San Francisco	Newcastle
Diamond Springs Lime Co.	a, b, c	Diamond Springs	Diamond Springs
El Dorado Limestone Co., J. H. Bell, Pres.	b	Shingle Springs	Shingle Springs
Fresno County			
Sierra Limestone Grits, Al Feuerstein	b	3863 Kershoff, Fresno 2	Fresno
Inyo County			
Blue Star Mines, Ltd.	b	Room 510, 810 S. Spring St., Los Angeles	Zurich
San Bernardino County			
Cal. Portland Cement Co.	a, b	601 W. Fifth St., Los Angeles	Colton
Chubbuck Lime Co., Chas. I. Chubbuck	a, b, c	4711 Worth St., Los Angeles	Chubbuck
Marter Mining Co.	b	530 W. Sixth St., Los Angeles	Lucerne Valley
Riverside Cement Co.	b	621 S. Hope St., Los Angeles	Oro Grande
Victorville Lime Rock Co.	b	Box 548, Victorville	Victorville
San Mateo County			
Pacific Portland Cement Co.	c, d	417 Montgomery St., San Francisco	Redwood City
Santa Clara County			
Bay Shell Co.	c, d	503 Market St., San Francisco	Alviso
Beck Dredging Co.	c, d	305 Parrott Dr., San Mateo	Alviso
Permanente Cement Co.	b	Permanente	Permanente
Santa Cruz County			
Henry Cowell Lime and Cement Co.	a, b	2 Market St., San Francisco	Santa Cruz
Pacific Limestone Prod. Co.	b, c	Spring St., Santa Cruz	Santa Cruz
Santa Cruz Portland Cement Co.	b	Crocker Bldg., San Francisco	Davenport

San Luis Obispo County			
Essential Industries, Inc.	b	Rm. 1006 Merchants Exchange Bldg., San Francisco	San Miguel
Siskiyou County			
Electro Lime & Chemical Co.	b	536 S. E. Sixth Ave., Portland, Ore.	Gazelle
Tuolumne County			
Walter C. Sundburg	b	Box 653, Sonora	Sonora
U. S. Lime Products Corp.	a, b, c	1840 E. 25th St., Los Angeles 11	Sonora
Ventura County			
Western Lime Products Co.	b, c	6305 Yucca St., Los Angeles	Santa Susana

* a. Producer of burnt lime. b. Producer of limestone. c. Agricultural lime. d. Shells.

LITHIA

Operator	Address	Location of mine
San Bernardino County		
American Potash & Chemical Corp.	3030 W. 6th St., Los Angeles 54	Trona

MAGNESIA AND OTHER MAGNESIUM COMPOUNDS

Operator	Product	Address	Location of plant
Alameda County			
The Paraffine Cos., Inc.	carbonate	Emeryville 8	Emeryville
Westvaco Chlorine Prod. Corp.	oxide	405 Lexington Ave., New York 17, N. Y.	Newark
Monterey County			
The Permanente Metals Corp.	oxide	P. O. Box 1531, Salinas	Moss Landing
San Diego County			
Westvaco Chlorine Prod. Corp.	chloride	405 Lexington Ave., New York 17, N. Y.	San Diego
San Mateo County			
Johns-Manville Products Corp.	basic carbonate	22 E. 40th St., New York 16, N. Y.	Redwood City
Marine Magnesium Prod. Corp., R. E. Clarke	carbonate hydroxide and oxide	South San Francisco	South San Francisco

MARBLE

Operator	Product*	Address	Location of quarry
San Bernardino County			
Rowe and Buehler	b	1555 Sunset Ave., Pasadena	Lavic
San Luis Obispo County			
Thomas C. Reynolds	b	Rt. 1A, Box 53, Paso Robles	Paso Robles

* b. Limestone used as building stone and flagstone.

MICA

Operator	Product*	Address	Location of mine
Imperial County			
Western Non-metallic Co., C. F. Allebrand	a	Ogilby	Ogilby

* a. Sericite mica schist.

MINERAL PAINT

Operator	Address	Location of property
San Bernardino County		
Rowe, Gabelic, & Buehler	1555 Sunset Ave., Pasadena	Ludlow

MINERAL WATER

Operator	Address	Location of spring
Butte County		
Richardson Mineral Springs	Richardson Springs	Richardson Springs
Calaveras County		
Mok-Hill Mineral Springs, Seven Up Bottling Co.	1360 46th St., Sacramento 17	Mokelumne Hill
Contra Costa County		
Alhambra Water Co.	Martinez	Martinez
Fox Water Co.	576 37th St., Oakland	Oak Springs
Lake County		
Bartlett Springs	Bartlett Springs, via Williams	Bartlett Springs
Norman Mineral Springs, Hazel J. Dabney	Middletown	Middletown
Witter Medical Springs, W. E. Whitaker	1265 Fourth Ave., San Francisco	Witter Springs
Los Angeles County		
Angelus Beverage Co.	308 N. Oxford St., Los Angeles	Los Angeles
Deep Rock Artesian Water	4416 York Blvd., Los Angeles	Los Angeles
Elysian Spring Water Co.	1536 Baxter, Los Angeles	Los Angeles
Frespuro Artesian Water	4430 York Blvd., Los Angeles	Los Angeles
Indian Head Mineral Water	3640 N. Griffin Ave., Los Angeles	Los Angeles
Magnetic Spring Water Co.	939 Hancock Ave., Los Angeles	Los Angeles
Mountain Spring Water Co.	226 S. Avenue, Los Angeles	Los Angeles
Sparklett Bottled Water Corp.	4500 York Blvd., Los Angeles	Los Angeles
Marin County		
Purity Spring Water Co.	2032 Kearny St., San Francisco	
Napa County		
Calistoga Bottling Works, Ernest Mainini	Calistoga	Calistoga
Grigsby Soda Springs, T. B. Grigsby	Monticello	Monticello
Napa Soda Water Co.	25 Taylor St., San Francisco	Napa Soda Springs
Orange County		
La Vida Mineral Springs Co.	Route 1, Placentia	Carbon Canyon

Riverside County		
Beulah Springs, Oscar C. McNicholl	Arlington	Arlington
San Benito County		
San Benito Mineral Springs	Rt. 1, Box 306, Hollister	
San Bernardino County		
Arrowhead & Puritas Waters, Inc.	1566 E. Washington Blvd., Los Angeles 21	Arrowhead
San Diego County		
Rock Springs Co., L. H. Walck	Route 2, Box 224-A, Escondido	Escondido
San Francisco County		
Blue Crest Beverage Co.	285 Naples St., San Francisco	San Francisco
San Luis Obispo County		
New Crystal Spring Water Co., Ellen M. Hudson	Route 2, Box 129, San Luis Obispo	San Luis Obispo
Santa Barbara County		
Veronica Sales Co., Ltd.	P. O. Box 1002, Santa Barbara	Santa Barbara
Shasta County		
Hilltop Spring Water Co.	Redding	Shasta
Siskiyou County		
The Shasta Water Co.	6th and Brannan Sts., San Francisco	Dunsmuir
Sonoma County		
Boyes Springs Mineral Water Co.	Boyes Springs	Boyes Springs
Barcal Springs, John Kolling	Cloverdale	Cloverdale
Tehama County		
Polk Springs	Box 154, Chico	Polk Springs

PLATINUM GROUP METALS

Operator	Address	Location of spring
Butte County		
Yuba Consolidated Gold Fields	351 California St., San Francisco	Oroville
Merced County		
Snelling Gold Dredging Co. (platinum metals not sold in 1947)	Snelling	Snelling
Sacramento County		
Natomas Co.	P. O. Box 1197, Sacramento	Natoma
Yuba County		
Yuba Consolidated Gold Fields	351 California St., San Francisco	Hammonton

POTASH

Operator	Address	Location of plant
San Bernardino County		
American Potash and Chemical Co.	3030 W. Sixth St., Los Angeles 54	Trona

PUMICE AND VOLCANIC ASH

Operator	Product*	Address	Location of property
Amador County			
M. J. Bacon	b	Ione	Ione
Calaveras County			
Brownlite Products	a	701 Laurel St., Modesto	Valley Springs
H. D. Warren	a	Rt. 1, Box 295, Linden	Burson
Contra Costa County			
Diablo Pumbloc Co., Gieg Bros.	a	Rt. 1, Box 163, Pittsburg	Pittsburg

Inyo County			
Desert Materials Corp.	a	6371 Wilshire Blvd., Los Angeles	Inyokern
Pacific Coast Pumice Co., C. W. Churchill	a	P. O. Box 656, Bishop	Bishop
Western Tale Co.	a	1901 E. Slauson Ave., Los Angeles	Shoshone
Kern County			
Cudahy Packing Co.	b	803 Macy St., Los Angeles	Ceneda
Madera County			
Calif. Industrial Minerals, c/o Forrest S. Taylor	b	Friant	Friant
Erickson, Elmer	a	Box 98, Friant	Friant
Pacific Pumice Materials Co., W. E. Schlink	a	1511 O St., Fresno	Friant
Pumice Industries	a, b	851 Balboa Bldg., San Francisco	Friant
Smith, Dave	a	P. O. Box 8, Friant	Friant
Modoc County			
Glass Mt. Volcolite Co., H. W. Free	a, c	Tionesta	Tionesta
Miers & Renstrom	a	Tionesta	Tionesta
Mono County			
Insulating Aggregate Co.	a	Bishop	Laws
U. S. Pumice Supply Co.	a, d	5509 Randolph St., Los Angeles	Leevining
Van Loon, H. A.	a	Bishop	Laws
Napa County			
Dalton M. Austin	a	Monticello Rd., Napa	Napa
Basalt Rock Co.	a	8th St., Napa	Napa
Pyro-Stop Plaster Co.	a	P. O. Box 446, Napa	Napa
John Q. Pearl	a	Box 2186, Monticello Rd., Napa	Napa
Siskiyou County			
Boorman Pumice Products	a	P. O. Box 624, Klamath Falls, Ore.	Tionesta
C. F. Enloe	a	Dorris	Tionesta
Fouch & Son, Roy	a	2236 College Ave., Berkeley 4	Tionesta
Glass Mt. Industries	d	434 S. 2nd St., Klamath Falls, Oregon	Tionesta
Glass Mt. Volcolite Co., H. W. Free	a, c, d	Tionesta	Glass Mountain
Renstrom	a, d	Tionesta	Tionesta
John Madsen	a, d	P. O. Box 71, Klamath Falls, Ore.	Tionesta
Sonoma County			
W. A. Wilson	a	St. Rt. Box 59, Petaluma	Cotati
Stanislaus County			
Base Materials, R. W. Lepper (Producing in 1948)	b	Patterson	Newman

* a. Pumice, aggregate. b. Volcanic ash. c. Scoria. d. Pumice for scouring brick.

PYRITES

Operator	Address	Location of mine
Shasta County		
The Mountain Copper Co., Ltd., Wm. F. Kett, Mgr.	216 Pine St., San Francisco	Matheson

QUICKSILVER

Mine	Operator	Address	Location of mine
Fresno County			
Archer	Archer Mining Co.	510 S. Spring St., Los Angeles	Coalinga
Lake County			
Sulphur Bank	Bradley Mining Co.	Crocker Bldg., San Francisco 4	Clearlake Park
Napa County			
Knoxville	Geo. E. Gamble (Owner)	Monticello	Monticello
San Benito County			
Juniper	Berg & Sciochetti	P. O. Box 637, Hollister	Panoche
New Idria	New Idria Quicksilver Mining Co.	Mills Bldg., San Francisco	Idria
San Luis Obispo County			
Buena Vista	J. E. Wyatt	Adelaide St., Paso Robles	Paso Robles
Santa Clara County			
Guadalupe	Laco Mining Co.	Rt. 3, Box 835, Los Gatos	Los Gatos
New Almaden Dump	Almaden Dumps	Almaden	Almaden
Sonoma County			
Culver Baer	C. A. Baumeister	Cloverdale	Cloverdale
Mt. Jackson	Sonoma Quicksilver Mines, Inc.	58 Sutter St., San Francisco	Guerneville
Yolo County			
Reed	Bradley Mining Co.	Crocker Bldg., San Francisco	Rumsey

SALT

Operator	Address	Location of plant
Alameda County		
American Salt Co.	341 Broadway, San Francisco 11	Mt. Eden
Leslie Salt Co.	310 Sansome St., San Francisco	Newark and Mt. Eden
Oliver Bros. Salt Co.	Mt. Eden	Mt. Eden
Kern County		
Long Beach Salt Co.	2436 Hunter St., Los Angeles	Saltdale
Mono County		
C. C. Miller	837 W. Los Angeles St., P. O. Box 365, Baldwin Park	Leevining
Monterey County		
Monterey Bay Salt Works, E. C. Vierra, Mgr.	Box 43, Moss Landing	Moss Landing
Orange County		
The Irvine Co.	Tustin, Box B	Newport Beach
San Bernardino County		
California Rock-Salt Co.	2436 Hunter St., Los Angeles	Amboy
Dale Chemical Industries, Inc.	P.O. Box 319, Twenty-nine Palms	Twenty-nine Palms
San Diego County		
Western Salt Co.	1245 National Ave., San Diego	Chula Vista

SANDSTONE

Operator	Product*	Address	Location of quarry
Los Angeles County			
Blue Goose Quarry, Robert Cox	b	1975 Lundy Ave., Pasadena	Pasadena
Madera County			
Carl E. Joplin & Son	a, b	Coarsegold	Coarsegold
Monterey County			
Carmel Stone Quarry, A. L. Possadori	c	Box 185, Carmel	Carmel
Napa County			
H. F. Galbreath	b	957 Regal Road, Berkeley	

* a. Dimension sandstone for building. b. Sandstone flagstone for building. c. Carmelstone for building.

SERPENTINE

Operator	Address	Location of quarry
Santa Clara County		
The Permanente Metals Corp.	Permanente	Almaden

SILICA

Operator	Product*	Address	Location of mine
Kern County			
N. W. Sweetser	c	Box 445, Rosamond	Rosamond
Mariposa County			
The Permanente Metals Corp.	a	Permanente	La Grande
Monterey County			
Del Monte Properties	b	Del Monte	Pacific Grove
Owens-Illinois Glass Co.	b	P. O. Box 359, Pacific Grove	Pacific Grove
Riverside County			
Owens-Illinois Glass Co.	b	P. O. Box 298, Corona	Corona
San Bernardino County			
Mineral Materials Co., C. W. Dunton, Mgr.	c	1145 Westminster Ave., Alhambra	Oro Grande
San Diego County			
Crystal Silica Co.	b	717 E. 61st St., Los Angeles	Oceanside

* a. Quartz. b. Glass sand. c. Quartzite.

Mine	Type of mine*	Operator	Address	Location of mine
Amador County				
Newton	j	Pacific Mining Co.	1022 Crocker Bldg., San Francisco	Ione
Calaveras County				
Penn	s	Shawmut Copper Mine Co.	Chinese Camp	Campo Seco
Inyo County				
Darwin and Shoshone group	m	Anaconda Copper Mining Co.	25 Broadway, New York, N. Y.	Darwin and Tecopa
Defense	m	Forman & Skinner	1354 2nd Ave., Salt Lake City, Utah	Keeler
Santa Rosa	m, c	Santa Rosa Mining Co. & Louis Warnken, Jr.	Keeler	Keeler
Shoshone group (Columbia No. 2)	m	Finley Co. (taken over by Anaconda Copper Mining Co. June 1, 1947)	Tecopa	Tecopa
Surprise	m	Foss & Osborn	441 Oxford Ave., Hawthorne	Panamint Spgs.
Modoc, Lane Eagle, and Wonder	x, v	L. D. Foreman	1354 2nd Ave., Salt Lake City, Utah	Darwin and Keeler
Kern County				
Tropico and others	a	Burton Brothers	Rosamond	Rosamond
Mono County				
Benton	v, c	L. D. Foreman	1354 2nd Ave., Salt Lake City, Utah	Benton
Nevada County				
Empire-Star group	a	Empire Star Mines Co., Ltd.	Grass Valley	Grass Valley
Idaho-Maryland & New Brunswick	a	Idaho-Maryland Mines Corp.	Grass Valley	Grass Valley
Sacramento County				
Natomas dredges	e	Natomas Co.	P. O. Box 1197, Sacramento	Natomas
San Bernardino County				
Carbonate King Zinc	o	J. Q. Little	Nipton	Nipton
Kelly	b	F. W. Royer	Randsburg	Randsburg
Mohawk	x	Mohawk Mines, Inc.	Nipton	Nipton
Silver Hill	v	W. R. Long Co.	Yermo	Yermo
Shasta County				
Hornet-Richmond	s, y	The Mountain Copper Co., Ltd.	216 Pine St., San Francisco	Matheson
Kennett Flue Dust (Mammoth)	u	C. E. Wuench & C. T. McNeil	300 Montgomery St., San Francisco	Kennett

* a. Lode gold mine. b. Gold-silver mine. c. Tailings dump. d. Pocket. e. Dredge (bucketline). g. Hydraulic mine. h. Dragline operation. j. Copper mine. k. Power shovel or dryland dredge. m. Lead mine. o. Zinc mine. r. Tungsten mine. s. Copper-zinc mine. t. Gravel plant. u. Smelter slag and flue dust. v. Silver mine. w. Silver-lead mine. x. Zinc-lead mine. y. Pyrites mine.

SLATE

Operator	Product*	Address	Location of quarry
El Dorado County			
Pacific Minerals Co., Ltd.	b, c	337 10th St., Richmond	Chili Bar
Inyo County			
Blue Star Mines, Ltd.	d	810 S. Spring St., Los Angeles	Zurich
Mariposa County			
Hanner Mining Co.	a, c	Le Grand	Le Grand
Placer County			
J. R. Hodgson	a	Box 88, Colfax	Colfax
Tuolumne County			
Walter C. Sundburg	a	Box 653, Sonora	Sonora

* a. Facing. b. Granules. c. Crude. d. Filler.

SODA

Operator	Product*	Address	Location of plant
Inyo County			
Natural Soda Products Co.	a, d	506 Central Tower Bldg., San Francisco 4	Keeler
Permanente Metals Corp.	a	Kaiser Bldg., Oakland	Lone Pine
Pittsburgh Plate Glass Co., Columbia Chemical Division	a, d	Bartlett	Bartlett
San Bernardino County			
American Potash & Chemical Co.	a, c	3030 W. 6th St., Los Angeles 54	Trona
Dale Chemical Industries, Inc.	c	P. O. Box 319, Twenty-nine Palms	Twenty-nine Palms
West End Chemical Co.	a	Latham Square Bldg., Oakland	Westend

* a. Soda ash. c. Salt cake. d. Trona.

STONE, MISCELLANEOUS

Under the heading of "miscellaneous stone" are four divisions—crushed rock, grinding mill pebbles, paving blocks, and sand and gravel. Crushed rock includes crushed rock that is used in macadam, ballast, and for concrete; also rock used for rubble and riprap.

NOTE—The California State Highway Commission, the various counties, cities, U. S. Forest Service, U. S. National Park Service, and U. S. Bureau of Public Roads produce both crushed rock and sand and gravel in various places in the State used in construction and maintenance of highways, but not specified in this listing.

Operator	Product*	Address	Location of pit or quarry
Alameda County			
California Rock & Gravel Co.	a	1800 Hobart Bldg., San Francisco	Livermore
Heafey-Moore Co., Leona Quarry	b	344 High St., Oakland	Oakland
Henry J. Kaiser Co.	a, b	Kaiser Bldg., 1924 Broadway, Oakland	Radum
Leslie Salt Co.	b	310 Sansome St., San Francisco	Newark
J. L. Martin	b	5921 Shepherd Canyon Rd., Oakland	Oakland
Niles Quarry Co.	b	406 Highland Blvd., Hayward	Hayward
Pacific Coast Aggregates, Inc.	a, b	400 Alabama St., San Francisco	El'ot and Niles
A. B. Pickard	a	300 S. Mary St., Pleasanton	Pleasanton
San Leandro Rock Co.	b	1150 Estudillo Ave., San Leandro	Lake Chabot
Tesla Clay & Sand Co.	a	220 Montgomery St., San Francisco	Tesla
Amador County			
Chas. Ayres	a	P. O. Box 266, Sutter Creek	Sutter Creek
Plymouth Rock Wool Co.	e	P. O. Box 127, Plymouth	Plymouth
Butte County			
Butte Creek Rock Co.	a, b	Centerville Rd., Chico	Chico
Henry J. Kaiser Co.	a, b	1924 Broadway, Oakland	Oroville
Calaveras County			
Neilsen Sand & Gravel Co.	a	Box 14, San Andreas	San Andreas
Colusa County			
Cortina Sand, Gravel and Silt, Gene Godin	a	Colusa	Colusa
Paul Entremont	a	Colusa	Princeton
Contra Costa County			
Antioch Ashphalt Co.	a	1806 30th Ave., San Francisco 22	Antioch
Atchison, Topeka & Santa Fe Railway Co.	a	121 E. Sixth St., Los Angeles 14	
Basalt Rock Co.	a	Eighth St., Napa	Antioch
Blake Bros., Anson Blake	b	Box 1002, Richmond	Point Richmond
Henry J. Kaiser Co.	a, b	1924 Broadway, Oakland	Antioch and Upton
Marchio Sand Co.	a	Antioch	Antioch
Roberts Sand Co.	c	Box 323, Pittsburg	Clayton
Serra Bros.	b	R. F. D. Rt. 1, Box 335, Martinez	Walnut Creek

Del Norte County			
Basalt Rock Co., Inc.	b	8th and River Sts., Napa	
John Burman & Sons	a	2750 Harrison Ave., Eureka	Crescent City
El Dorado County			
Diamond Springs Lime Co.	b	Diamond Springs	Diamond Springs
Fresno County			
Atchison, Topeka & Santa Fe Railway Co.	b, g	121 E. Sixth St., Los Angeles 14	Oakhurst Piedra
Central Rock & Sand Co.	a	Sanger	Sanger
Herndon Rock Products Co.	a	410 Thorne St., Fresno	Herndon
Pacific Coast Aggregates, Inc.	a, b	400 Alabama St., San Francisco	Rockfield
Sharp & Fellows Construction Co.	b	533 Central Bldg., San Francisco	
Southern California Edison Co.	a, b	Edison Bldg., Los Angeles 53	
Thompson Materials & Construction Co., Inc.	a	Avenal	Avenal
Glenn County			
E. B. Bishop & Edward Thomas dba Orland Sand & Gravel Co.	a	P. O. Box 469, Orland	Orland
L. G. Madsen & F. A. Carmer	a	Willows	Willows
Southern Pacific Co.	a	65 Market St., San Francisco	Wyo
Humboldt County			
Tom Hull	a, b	Eureka	Arcata
Mercer Fraser Co., Essex & Fernbridge	a	Second and Commercial Sts., Eureka	Hoopa, Arcata & Fortuna
Northwestern Pacific R. R. Co.	a	San Rafael	Sequoia
Imperial County			
Donald Cowan	a	El Centro	Holtville
Imperial Sand & Rock Co.	a	Brawley	Brawley
Lucien E. Smith Pipe Yard	a	Rt. 2, Box 270, El Centro	Seeley
Inyo County			
Bishop Engineering & Construction Co.	a, b	Bishop	Bishop
Mt. Whitney Rock Products, G. L. Watterson	a	Lone Pine	Lone Pine
Kern County			
Edison Sand Co.	a	Box 395, Sta. A, Bakersfield	Bakersfield
Griffith Co.	a, b	Bakersfield	Bakersfield
Hartman Concrete Materials	a, b	P. O. Box 1632, Bakersfield	Bakersfield & Maricopa
Kern Rock Co., Ltd.	a, b	P. O. Box 1697, Bakersfield	Kern River
Union Paving Co.	a	163 Sutter St., San Francisco	Oildale

* Key to symbols is at end of table.

STONE, MISCELLANEOUS—Continued

Operator	Product*	Address	Location of pit or quarry
Lake County			
Aggrelite Co., John C. McFayden	b	1734 Webster St., Oakland	
Frazell & Evans Bros.	a	Kelseyville	Kelseyville
E. H. Pyzer	b	Lakeport	Lakeport
Williams Rock & Sand Co.	a	Middletown	Middletown
Lassen County			
Grayson & Spurgeon Cement & Gravel Co.	a, b	1512 4th St., Susanville	Susanville
Los Angeles County			
Arrow Rock Co.	a	2815 Glendale Blvd., Los Angeles	Monrovia & Roscoe
A. T. & S. F. R. R., I. L. Hibbard, Gen. Mgr.	a	121 E. Sixth St., Los Angeles 14	Forbes
Azusa Rock & Sand Co.	a, b	P. O. Box 175, Azusa	Azusa
Guy F. Atkinson	b	P. O. Box 259, Long Beach	
Richard R. Ball	a	Box 96, Walteria	Walteria
Blue Diamond Corp., Ltd.	a	1650 S. Alameda St., Los Angeles	El Monte and Roscoe
Wm. J. Bonfield	g	2008 Laurel Canyon Rd., Los Angeles	Hollywood
Chandler Sand & Gravel, L. Chandler	a	Lomita	Lomita
City Rock Co.	a, b	P. O. Box 8, Sunland	Sunland
Consolidated Rock Products Co.	a, b	Box 2950 Terminal Annex or 2730 S. Alameda St., Los Angeles	Los Angeles, Azusa, Roscoe, Monrovia, Baldwin Park, and North Hollywood
Graham Bros., Inc.	a, b	2000 N. Peck Road, El Monte	El Monte
Granite Materials Co.	a, g	P. O. Box 368, Roscoe	Roscoe
John D. Gregg	a, b	Box 110, Whittier	Roscoe
Hanwalt Bros.	b	Box 187, La Verne	Pomona
Leibee Engineering Co., Inc.	b	124 W. Sixth St., Los Angeles	El Segundo
Lindauer Corp.	a	Box 337, La Habra	La Habra
Livingston Truck & Materials Co.	g	3366 Cherry St., Long Beach 7	Rolling Hills
Los Angeles Decomposed Granite Co.	g	2171 W. Washington, Los Angeles	Montebello
Manning Bros. Rock & Sand Co.	a, b	Irwindale	Irwindale
Mission Rock & Sand Co.	a	1172 La Presa Dr., San Gabriel	San Gabriel
Owl Rock Products Co.	a, b, g	420 S. Alameda St., Compton	Monrovia
Pacific Rock & Gravel Co.	a, b	800 Lane Mortgage Bldg., 208 W. Eighth St., Los Angeles	Monrovia
Santa Catalina Island Co.	b	Box B-2, Avalon	Pebble Beach
Edwin Sidebotham & Sons, Sidebotham Sand Plant	a	751 E. L St., Wilmington	Lomita
Walter E. Wuesthoff	b	3208 Castera St., Glendale 8	Glendale

Marin County			
Basalt Rock Co.	b	Eighth St., Napa	McNear Point
Hutchinson Co.	b	Box 156, El Cerrito	San Quentin
Marin Gravel Co.	a	Point Reyes	Point Reyes
Mariposa County			
Gordon Grecnamger	a	Mariposa	Mariposa
Mendocino County			
Ford Gravel Co., Kirby Ford	a	Ukiah	Ukiah
John Freitas, Ukiah Gravel & Cement Co.	a	Ukiah	Ukiah
A. R. McEwing	a, b	Willits	Willits
Williams & Baxman	a	Fort Bragg	Fort Bragg
Merced County			
J. C. Halbert, Merced S. & G. Co.	a	Winton	Winton
Los Banos Gravel Co.	a	Los Banos	Los Banos
Sunset Gravel Co.	a	P. O. Box 965, Los Banos	Los Banos
Modoc County			
Great Northern Railway, T. A. Jerrow, Supt.	e	Klamath Falls, Ore.	Mammoth
Monterey County			
Del Monte Properties, C. S. Olmsted	a, c	Del Monte	Pacific Grove
Monterey Sands, H. W. Kolar	a	Marina	Marina
M. J. Murphy, Inc.	a	P. O. Box 100, Carmel	Carmel
Pacific Coast Aggregates, Inc.	a	400 Alabama St., San Francisco	Lapis and Pratteo
Napa County			
Basalt Rock Co.	b	Eighth St., Napa	Napa
Juarez Quarry, M. G. Reidenbach	b	Napa	Napa
Harold Smith	a	St. Helena	St. Helena
Orange County			
Geo. T. Calhoun	a	P. O. Box 1741, Santa Ana	Anaheim
California Rock Co.	a	Rural Delivery, Orange	Orange
Consoldated Rock Products Co.	a, b	2730 S. Alameda St., Los Angeles	Fullerton and Orange
Foster Sand & Gravel Co.	g	915 S. Spadra Rd., Fullerton	Orange
A. E. Fowler & Sons	a	Rt. 1, Box 19-A, Orange	Orange
V. J. Frye Foundry Supplies	c	1302 N. Flower St., Santa Ana	Santa Ana
Graham Bros., Inc.	a	2000 N. Peck Road, Los Angeles	San Juan Capistrano
D. D. Lawhead	g	Seal Beach	Seal Beach
Sully-Miller Construction Co.	a	1500 W. 7th St., Long Beach	El Modena
Plumas County			
Fredrickson & Watson	b	873 18th St., Oakland	

* Key to symbols is at end of table.

STONE, MISCELLANEOUS—Continued

Operator	Product*	Address	Location of pit or quarry
Placer County			
J. R. Hodgson	b	Box 88, Colfax	Colfax
Union Granite Co., Ruhkala Bros.	b	Rocklin	Rocklin
Riverside County			
Guy F. Atkinson Co.	b	1103 Heartwell Bldg., Long Beach	Bly Junction
A. T. & S. F. R. R. Co., I. L. Hibbard, Gen. Mgr.	b	121 E. Sixth St., Los Angeles 14	Box Springs
Geo. Hurz & Co.	a	P. O. Box 191, San Bernardino	San Bernardino
Emil Johnson	b	Perris	Perris
Massey Rock & Sand Co.	a	Indio	Indio
Mission Indians	a	Palm Springs	Palm Springs
Palm Springs Bldrs. Supply Co.	a	Palm Springs	Palm Springs
San Gorgonio Rock Products	a	P. O. Box 1414, Banning	Banning
A. E. Schwabacher	g	610 Market St., San Francisco	
Service Rock Co.	a	Box 309, Riverside	Riverside
Transit Mixed Concrete Co.	a, b	3464 E. Foothill Blvd., Pasadena	Corona
Valley Rock & Sand Corp.	a	San Jacinto	San Jacinto
Sacramento County			
American River Sand & Gravel Co.	a	P. O. Box 156, Perkins	Perkins
Brighton Sand & Gravel Co.	a, b	P. O. Box 2604, Sacramento	Perkins
Canon & Co.	c	Box 812, Sacramento	North Sacramento
Del Paso Rock Products Co.	a, b	3040 Fair Oaks Blvd., Sacramento	Del Paso
Fair Oaks Gravel Co.	a	1401 42nd St., Sacramento 6	Fair Oaks
Harms Bros.	a	5261 Stockton Blvd., Sacramento	Sacramento
McGillivray Construction Co.	a	P. O. Box 873, Sacramento	Sacramento
Pacific Coast Aggregates, Inc.	a, b	400 Alabama St., San Francisco	Fair Oaks, Prattrock and American River
Perkins Gravel Co.	a, b	Perkins	Perkins
J. R. Reeves	a, b	P. O. Box 1072, Sacramento	Sacramento
Robert Powell & Co.	a	Box 815, Sacramento	American River
San Benito County			
Granite Rock Co.	b	Drawer M, Watsonville	Logan
A. Teichert & Son, Inc.	b	P. O. Box 1113, Sacramento 5	Hollister
San Bernardino County			
A. T. & S. F. R. R.	a, b	600 Kerckhoff Bldg., Los Angeles	Newberry
Concrete Rock & Sand Co.	a	P. O. Box 149, Colton	Colton
Consolidated Rock Products Co.	a, b	2730 S. Alameda St., Los Angeles	Claremont
Fontana Gravel Co.	a	Fontana	Fontana
Geo. Herz & Co.	a	Base Line & Lytle Sts., San Bernardino	San Bernardino
Holiday Rock Co.	a	Upland	Upland
Mineral Materials Co.	a	1145 Westminster Ave., Alhambra	Oro Grande

Redlands Gravel Co.	a	305 S. Buena Vista St., Redlands	Redlands
San Bernardino Rock & Gravel Co.	a	Box 249, San Bernardino	San Bernardino
Triangle Rock & Gravel Co.	a	San Bernardino	San Bernardino
Union Pacific Railroad Co.	a	2025 Hunter St., Los Angeles	Baxter
San Diego County			
Canyon Rock Co.	a, b	Box F, Hillcrest Sta., San Diego	San Diego
Claudell & Johnson	a	Box 246, Hillcrest Sta., San Diego	Mission Valley
Crystal Silica Co.	a, c, h	717 E. 61st St., Los Angeles	Oceanside
Daley Corp.	a	Mission Valley & Ward Rd., San Diego	San Diego
H. G. Fenton Materials Co.	a	1245 National Ave., San Diego	San Diego
Hubbard Molding Sand Co.	c	2700 Barnson Pl., San Diego	San Diego
John T. Momand	f	P. O. Box 381, Carlsbad	Carlsbad
Nelson & Sloan	a	Box 488, Chula Vista	Chula Vista
Oceanside Rock & Sand Co.	a	Oceanside	Oceanside
Arthur & Fred Woodward	a	Rt. 2, Box 190-M, San Diego	San Diego
San Joaquin County			
Frank P. Brendel & Spencer S. Decker	a	1705 Oxford St., Berkeley	Stockton
Frank B. Marks & Sons	a, b	203 Berverdor, Tracy	Tracy
Pacific Coast Aggregates, Inc.	a, b	400 Alabama St., San Francisco	Riverbank, Tracy
Peters Sand & Gravel Co.	a	3439 Sonoma St., Stockton	Riverbank
Pereira Bros.	a, b	Tracy	Tracy
Putnam Sand & Gravel Co.	a	P. O. Box 486, Modesto	Riverbank
Santa Fe Sand & Gravel Co.	a	Box 385, Escalon	Escalon
Sivers & Stigelmayer, Mokelumne Pit	a	Clements	Clements
Tracy Rock & Gravel Co.	a	2101 Weber St., Stockton	Stockton
Chas. D. Warner & Son, Inc.	a	247 Waterford Rd., Modesto	Waterford
Clyde Wood	a	686 E. Lockwood St., Lodi	Clements
San Luis Obispo County			
Walter B. Roselip	a	Box 551, San Luis Obispo	Atascadero
San Mateo County			
A. & B. Quarry	b	P. O. Box 1037, Redwood City	Woodside
Brisbane Rock Co.	b	Guadalupe Valley, Brisbane	Brisbane
Brumley-Donaldson Co.	c	557 Howard St., San Francisco	South San Francisco
Canadas Quarry, California Paving Co.	b	1406 Third Ave., San Mateo	Half Moon Bay
Golden West Quarry	b	Geneva Ave. and Santos St., San Francisco 24	Daly City
Holy Cross Cemetery	b	Colma	Colma
Keeble & Brown	b	San Mateo	Belmont
Macco-Morrison-Knudsen Co.	b	P. O. Box 207, San Bruno	Millbrae
H. Morton	b	Box 192, Menlo Park	Redwood City
San Mateo Feed & Fuel Co.	b	840 San Mateo Dr., San Mateo	Belmont
Rockaway Quarry, Inc.	a, b	Rockaway Beach	Rockaway Beach
Ken Royce	b	185 Bayshore Blvd., San Francisco	Rockaway Beach
Shoreland Co.	b	Pescadero	Pescadero

* Key to symbols is at end of table.

STONE, MISCELLANEOUS—Continued

Operator	Product*	Address	Location of pit or quarry
Santa Barbara County			
Henry G. Petersen, dba Buell Flat Rock Co.	a, b	Solvang	Solvang
Southern Pacific Milling Co.	a	c/o Rock Plant, 206 Sansome St., San Francisco	Santa Maria
Santa Clara County			
Henry Faber	b	645 Williams, Palo Alto	
Los Gatos Sand and Gravel Co.	a	Los Gatos	Los Gatos
George Neary	b	Rt. 1, Box 604, Los Altos	Los Altos
Pacific Coast Aggregates, Inc.	a, b	400 Alabama St., San Francisco	Coyote and Campbell, San Jose
Permanente Cement Co.	b	Permanente	Permanente
Leo F. Piazza	b	175 S. Montgomery St., San Jose	
A. J. Raisch Paving Co.	a	900 W. San Carlos St., San Jose	San Jose
Rhodes & Robinson, Stanford Quarry	b	Box 325, Palo Alto	Palo Alto
Western Gravel Corp.	b	P. O. Box 855, Campbell	Campbell
Santa Cruz County			
Henry J. Kaiser Co.	a	1924 Broadway, Oakland	Olympia
Pacific Coast Aggregates, Inc.	a	400 Alabama St., San Francisco	Olympia
Santa Cruz Portland Cement Co.	b	Crocker Bldg., San Francisco	Davenport
Shasta County			
Fairy-Hammond & R. A. Farish	a	564 Market St., San Francisco	Millville
J. H. Hein Co.	a, b	Redding	Redding
Siskiyou County			
John S. Jensen & M. N. Thompson	a	Mt. Shasta	Mt. Shasta
Southern Pacific R. R. Co., Ass't. Chief Engineer	e	Southern Pacific Bldg., San Francisco	Kegg
A. Young	a	345 N. Main St., Yreka	Yreka
Solano County			
Delta Construction Co., Norman Brown	a	Box 457, Rio Vista	Vacaville
Frederickson Bros.	b	1259 65th St., Emeryville	
J. M. Nelson, Cordelia Quarry	b	Cordelia	Cordelia
Sonoma County			
Basalt Rock Co.	a, b	Eighth St., Napa	Healdsburg
Hein Bros. Basalt Rock Co., Mark Hein, Pres.	b	Petaluma	Petaluma
R. D. Pellock	b	Rt. 3, Box 615, Sebastopol	Sebastopol
J. P. Serres	a	Agua Caliente	Agua Caliente
John C. Spaletta	a	P. O. Box 442, Santa Rosa	Santa Rosa
Stony Point Quarry, W. A. Wilson	b	Petaluma, Star Route	Stony Point
Taylor Gravel Co., Harvey Taylor	a	Healdsburg	Healdsburg

Stanislaus County			
D. & L. Truck Terminal	b	Oakdale	Oakdale
Hubert H. Everist, Sr.	a	P. O. Box 100, Westley	Westley
Gravel Products Co.	a	Hughson	Hughson
Wes Haslan	a, b	Oakdale	Oakdale
Johnson Bros.	a	P. O. Box 123, Modesto	Modesto
Frank B. Marks & Sons	a	203 Berverdor St., Tracy	Newman
Oakdale Irrigation Dist.	a	Oakdale	Oakdale
Putnam Sand & Gravel Co.	a	P. O. Box 486, Modesto	Modesto
J. P. Scanlon, Scanlon Gravel Pit	a	Patterson	Crows Landing
C. Skove & J. Wyehopen	a	Rt. 1, Box 27, Turlock	Turlock
Chas. Warner	a	Modesto	Modesto
Tehama County			
Baker Trucking Co.	b, c	Hamilton City	Hamilton City
Archie Draper & Floyd Adams	a, b	Red Bluff	Red Bluff
Liston Ehorn	a	926 Jackson St., Red Bluff	Red Bluff
Wm. G. Taber	a	Red Bluff	Red Bluff
Trinity County			
Northwestern Pacific R. R. Co., Wm. N. Neff, Gen. Supt.	b	Sausalito	Island Mountain
Tulare County			
O. C. Jeffers	a	1032 River Rd., Porterville	Porterville
Pacific Coast Aggregates, Inc.	a, b	400 Alabama St., San Francisco	Lindsay
Sequoia Rock Co.	a	P. O. Box 133, Lemon Cove	Lemon Cove
Tuolumne County			
Beerman & Jones	a, b	Sonora	Soulsbyville
Ventura County			
Montalvo Rock Co.	a, b	Box 188, Montalvo	Montalvo
Santa Paula Rock Co.	a	Santa Paula	Santa Paula
Saticoy Rock Products Co.	a, b	Box 970, Ventura	Saticoy-Ventura
Ventura Molding Sand Co., O. D. Messmore	c	182 W. Simpson St., Ventura	Ventura
Yolo County			
Frank Goodin	a	Woodland	Woodland
Leroy Kerr	a	Yolo	Yolo
Schwarzgruber & Sons	a	Woodland	Woodland
J. Dudley Stephens	a	Woodland	Woodland
George Summers	a	810 Elm St., Woodland	Woodland
Woodland Gravel Co.	a	Woodland	Woodland
Mrs. Lucy L. Woods	a	Woodland	Woodland

* Key to symbols is at end of table.

STONE, MISCELLANEOUS—Continued

Operator	Product*	Address	Location of pit or quarry
Yuba County			
Hallwood Sand & Gravel Co.	a	711 Wilkie Way, Yuba City	Marysville
Pacific Coast Aggregates, Inc.	a	400 Alabama St., San Francisco	Marysville
Rice Bros.	a	P. O. Box 1446, Modesto	Marysville
Yuba River Sand Co.	a	Marysville	Marysville

* a. Sand and gravel. b. Crushed rock (macadam, ballast, rubble, riprap, etc.). c. Molding sand. d. Granules for roofing, terrazzo. e. Slag and volcanic cinder. f. Tube-mill pebbles. g. Decomposed granite. h. Filter sand.

STRONTIUM

Operator	Address	Location of mine
San Bernardino County		
Rowe-Buehler Mining Co., Wesley N. Rowe	1555 Sunset Ave., Pasadena	Lavic

SULPHUR

Operator	Address	Location of mine
Alpine County		
Siskon Mining Corp., Hugh Wright, Gen. Mgr. (development work only, no shipments made during year.)	812 Subway Terminal Bldg., Los Angeles 13	Markleeville
Inyo County		
Crater Group, R. E. Kitching	P. O. Box 783, Big Pine	Big Pine
S. & M. Minerals Co., B. J. Miche	P. O. Box 651, Big Pine	Big Pine

Operator	Product*	Address	Location of mine
El Dorado County			
Pacific Minerals Co., Ltd.	a	337 10th St., Richmond	Shingle
Inyo County			
Stuart M. Anderson	b	Box 11, Darwin	Darwin
William Bonham & Bernice Bonham	b	Lone Pine	Keeler
Branson & Cowsert	b	Keeler	Keeler
F. Tyler Daniels	b	Darwin	Darwin
Louise Grantham	b	809 6th St., Ontario	Shoshone
F. M. Henderson	b	Box 24, Moapa, Nev.	Big Pine
C. W. James	b	Keeler	Darwin
George W. Koest (Viking Talc)	b	929 S. Detroit St., Los Angeles	Keeler
Tin Mattix, et al	c	Laws	Laws
James F. Nikolaus & Jack Lane	b	109 S. Main St., Big Pine	Big Pine
Raymond Palmer	b	Keeler	Keeler
Sierra Talc & Clay Co.	b	5509 Randolph St., Los Angeles 22	Keeler and Tecopa
Wm. V. Skinner	b	Keeler	Keeler
C. A. Stanley & H. R. Gray	b	Lone Pine	Keeler
Stewart & Taylor	b	Big Pine	Big Pine
Taylor Bros.	b	Big Pine	Big Pine
Los Angeles County			
Dr. Leon Katz	a	3239 Weldon Ave., Los Angeles 41	Acton
Mono County			
Huntley Industrial Minerals, Inc.	c	P. O. Box 305, Bishop	Laws
San Bernardino County			
Desert Talc & Clay Co.	b	Pomona	Barstow
Sierra Talc Co.	b	5509 Randolph St., Los Angeles 22	Silver Lake and Baker
Southern Calif. Minerals Co., W. S. Skeoch	b	320 S. Mission Rd., Los Angeles	Cima and Shoshone
Western Talc Co.	b	1901 E. Slauson Ave., Los Angeles	Death Valley
San Diego County			
Pioneer Pyrophyllite Products	c	Box 686, Chula Vista	Rancho Santa Fe
Tuolumne County			
Walter C. Sundburg	a	Box 653, Sonora	Sonora

* a. Soapstone. b. Talc. c. Pyrophyllite.

TITANIUM

Operator	Address	Location of mine
Los Angeles County		
Challoner Thompson (expects to produce in 1948)	Sand Canyon Rt. 1, Saugus	Saugus
Ferro-Titan Minerals Co., N. C. Amen & F. M. Moody	212 Bank of America Bldg., Glendale	Saugus

TUNGSTEN

Mine	Operator	Address	Location of mine
Alpine County			
Alpine	Alpine Mining Co.	P. O. Box 114, Gardnerville, Nev.	Markleeville
Fresno County			
Garnet Dike	Sheridan & Bennett	Kings River Hatchery	Kings River
Victor	V. K. Horton, et al	Modesto	Shaver Lake
Inyo County			
Brownstone	El Diablo Mining Co.	Box 567, Bishop	Bishop
Hanging Valley	Hanging Valley Tungsten Co.	1545 W. 87th St., Los Angeles 44	Bishop
Pine Creek	U. S. Vanadium Co.	30 E. 42nd St., New York, N. Y.	Bishop
Tungstar	Tungstar Corp.	Box 725, Bishop	Bishop
Kern County			
Rand	Kubon & Jurva	4104 W. 104th St., Inglewood	Glennville
Tungsten Chief	W. C. Thompson	Caliente	Caliente
Mono County			
Black Rock	Beauregard, A. E., S. H., John	Bishop	Benton
San Bernardino County			
Spud Patch Placers & Atolia	Surcease Mining Co.	1820 D St., Sacramento	Atolia
Tulare County			
Crystal Queen	Orton & Janoko	Porterville	Lemon Cove
Harrel Hill	Consolidated Tungsten	Box 366, Dinuba	Orosi
Herbert	Herbert Mines	Rt. 5, Box 150A, Porterville	Porterville
Big Jim	Tulare County Tungsten Mines	Box 361, Lindsay	Lindsay
Sherman Peak	Embree & Eliason Mining Co.	P. O. Box 583, Kernville	Kernville
(Tailings)	Helm & Green	Orosi	Orosi

ZINC

Mine	Operator	Address	Location of mine
Calaveras County			
Penn	Shawmut Copper Mine Co.	Chinese Camp	Campo Seco
El Dorado County			
Pioneer-Lilyama	Pioneer-Lilyama Mines	Placerville	Placerville
Inyo County			
Darwin and Shoshone groups (Columbia No. 2)	Anaconda Copper Mining Co.	25 Broadway, New York, N. Y.	Darwin and Tecopa
Gold Bottom-Ophir	Damon & Damon	1612 Oregon St., Redding	Trona
Old Timer	C. W. James	Lone Pine	Lone Pine
Ubehebe	Ubehebe Mines, Inc.	356 So. Spring St., Los Angeles	Owenyo
San Bernardino County			
Atolia	Surcease Mining Co.	Box 786, Sacramento	Randsburg
Carbonate King Zinc	J. Q. Little	Nipton	Nipton
Mohawk	Mohawk Mines, Inc.	Nipton	Nipton
Shasta County			
Hornet-Richmond	The Mountain Copper Co., Ltd.	216 Pine St., San Francisco	Matheson
Kennett Flue Dust (Mammoth)	C. E. Wueneh & C. T. McNeil	300 Montgomery St., San Francisco	Kennett

LIST OF SMELTERS AND MINERAL DEALERS REPORTING PURCHASE OF CALIFORNIA METALS PRODUCED IN 1947

Name	Address	Location of plant	Metals reported purchased
American Smelting & Ref. Co.	120 Broadway, New York, N. Y.	Garfield, Utah	Copper, lead, gold, silver
American Smelting & Ref. Co.	120 Broadway, New York, N. Y.	Hayden, Arizona	Copper, gold, silver
American Smelting & Ref. Co.	120 Broadway, New York, N. Y.	Murray, Utah	Lead, copper, gold, silver
American Smelting & Ref. Co.	405 Montgomery St., San Francisco	Selby, California	Copper, lead, gold, silver
American Smelting & Ref. Co.	120 Broadway, New York, N. Y.	Tacoma, Washington	Copper, lead, gold, silver
Anaconda Copper Mining Co.	25 Broadway, New York 4, N. Y.	Great Falls, Mont.	Copper, lead, zinc, gold, silver
C. L. Ach	2709 Birch St., Alhambra	Alhambra	Tungsten
Bethlehem Pacific Coast Steel Corporation	20th & Illinois Sts., San Francisco	San Francisco	Iron ore
Bradley & Ekstrom	320 Market St., San Francisco	San Francisco	Manganese, chromite, iron ore
Braun Corporation	2260 E. 15th St., Los Angeles	Los Angeles	Quicksilver
Coast Chemical Division F. W. Berk & Co., Inc.	Sharon Bldg., San Francisco	San Francisco	Quicksilver
International Smelting & Ref. Co.	Kearns Bldg., Salt Lake City, Utah	Tooele, Utah	Copper, lead, zinc, gold, silver
Kaiser Co., Inc.	P. O. Box 217, Fontana	Fontana	Iron ore, manganese ore, chromite
Mefford Chemical Co.	1026 Santa Fe, Los Angeles	Los Angeles	Quicksilver
Pacific Vegetable Oil Co., Bernard T. Rocca	62 Townsend St., San Francisco	San Francisco	Quicksilver
Quicksilver Producers Ass'n., Irving Ballard, Sec'y.	407 Sansome St., San Francisco	San Francisco	Quicksilver
Twining Laboratories	2527 Fresno St., Fresno	Fresno	Tungsten ore
U. S. Mint	Duboce & Market Sts., San Francisco	San Francisco	Gold, silver
U. S. Smelting, Refining & Mining Co.	Newhouse Bldg., Salt Lake City, Utah	Midvale, Utah	Copper, lead, zinc, gold, silver
Western Gold & Platinum Works	589 Bryant St., San Francisco	San Francisco	Platinum, gold, silver*
Wildberg Bros. Smelting & Ref. Co.	742 Market St., San Francisco	San Francisco	Platinum, gold, silver*

* Gold and silver in special high-grade ores only.

LIST OF MINERAL DEALERS, CUSTOM MILLS, AND COMMERCIAL GRINDING PLANTS IN CALIFORNIA

Firm	Notes
American Minerals Co., 2570 E. 8th St., Los Angeles 23, Calif.	Commercial grinding of minerals.
Atkins, Kroll & Co., 277 Pine St., San Francisco, Calif.	Dealers in tungsten ores, mercury, gypsum and limerock.
Bishop Concentrate & Cleaning Co. Bishop, Calif.	Custom mill; purchases tungsten ores and base metal ores.
Harry E. Blood Co., 112 W. 9th St., Los Angeles, Calif.	Dealers in industrial sand and silica products.
Blue Star Mines, Ltd., 810 S. Spring St., Los Angeles 14, Calif. (Mill at Zurich)	Dealer in talc, clay, and limestone.
Bond Bros. & Co., 461 Market St., San Francisco, Calif.	Dealers in export minerals.
Bradley & Ekstrom, 320 Market St., San Francisco, Calif.	Dealers in all commercial minerals.
Gerald A. Brown Box 463, Hermosa Beach, Calif.	Dealer in non-ferrous ores, chromite, and manganese ore.
Brumley-Donaldson Co., 557 Howard St., San Francisco, Calif., and 3050 E. Slauson Ave., Huntington Park, Calif.	Dealer in sand, clay, limestone, dolomite, and other minerals.
Burton Bros., Rosamond, Calif.	Custom cyanide mill. Gold and silver ores purchased.
Chamberlain Co., 4700 District Blvd., Los Angeles, Calif.	Dealer in fluorspar.
Commercial Minerals Co., 310 Irwin St., San Francisco, Calif.	Commercial grinding by contract or minerals purchased.
Dailey Chemical Laboratories, Box 228, Oroville, Calif.	Custom mill for black sands.
Empire Star Mines Co., Ltd., Grass Valley, Calif.	Amalgamation and cyanide mill; gold ore purchased.
Hidecker Brick Co., 2500 E. 8th St., Los Angeles, Calif.	Clay grinding plant; non-metallic minerals ground by contract or purchased.
Holmestake Mining Co., P. O. Box 308, Winterhaven, Calif.	Cyanide mill; gold and silver ores purchased.

LIST OF MINERAL DEALERS, CUSTOM MILLS, AND COMMERCIAL GRINDING PLANTS IN CALIFORNIA—Continued

Firm	Notes
Huntley Industrial Minerals, P. O. Box 305, Bishop, Calif.	Dealers in talc, pyrophyllite, and garnet sands.
Industrial Minerals & Chemical Co., 6th and Gilman Sts., Berkeley, Calif.	Non-metallic minerals ground by contract or purchased.
Charles G. Hardy, 7750 Madison St., Paramount, Calif.	Non-metallic minerals ground by contract or purchased; roofing granules prepared.
Kennedy Minerals Co., 2550 E. Olympic Blvd., Los Angeles, Calif.	Non-metallic minerals ground by contract or purchased.
Los Angeles Chemical Co., 1960 S. Santa Fe Ave., Los Angeles, Calif.	Non-metallic minerals grinding plant; contract or purchased.
Southern California Minerals Co., 320 S. Mission Road, Los Angeles, Calif.	Non-metallic mineral grinding plant; contract or purchased.
Pacific Minerals Co., Ltd., 337 10th St., Richmond, Calif. (Mill at Placerville)	Non-metallic minerals ground by contract or purchased.
Sierra Talc & Clay Co., 5509 Randolph St., Los Angeles 22, Calif.	Dealers in talc and clays.
Twining Laboratories, 2527 Fresno St., Fresno, Calif.	Purchase and concentrate tungsten ores on a custom basis, also commercial grinding.
Western Talc Co., 1901 E. Slauson Ave., Los Angeles, Calif.	Non-metallic mineral grinding plant; contract or purchased.

LIST OF QUICKSILVER BUYERS

F. W. Berk & Co., Coast Chemical Division,
55 New Montgomery St.,
San Francisco, Calif.

Braun Corporation,
2260 E. 15th St.,
Los Angeles, Calif.

H. W. Gould & Co.,
Mills Bldg.,
San Francisco, Calif.

Los Angeles Chemical Co.,
1960 South Santa Fe Ave.,
Los Angeles, Calif.

Mefford Chemical Co.,
1026 Santa Fe Ave.,
Los Angeles, Calif.

Pacific Vegetable Oil Co.,
407 Sansome St.,
San Francisco, Calif.

Quicksilver Producers Association,
407 Sansome St.,
San Francisco, Calif.

LIST OF COMMERCIAL ASSAY AND TESTING LABORATORIES

San Francisco Area

Ball, C. M.,
615 University Ave.,
Berkeley, Calif.

Curtis & Thomkins,
236 Front St.,
San Francisco, Calif.

Hall Laboratories, Inc.,
149 California St.,
San Francisco, Calif.

Hanks, Abbott A., Inc.,
624 Sacramento St.,
San Francisco, Calif.

Hersey Inspection Bureau (engineers, chemists, and testers of building materials),
3405 Piedmont Ave.,
Oakland, Calif.

Hunt, Robert W., Co.,
251 Kearny St.,
San Francisco, Calif.

Metallurgical Laboratories,
604 Mission St.,
San Francisco, Calif.

Multiphase, Inc.,
351 Eighth St.,
San Francisco, Calif.

Pacific Chemical Laboratories,
617 Montgomery St.,
San Francisco, Calif.

Pittsburgh Testing Laboratories,
651 Howard St.,
San Francisco, Calif.

Straub Manufacturing Co.,
507 Chestnut St.,
Oakland, Calif.

Western Analytical Bureau,
690 Market St.,
San Francisco, Calif.

Western Gold and Platinum Works,
589 Bryant St.,
San Francisco, Calif.

Wildberg Bros.,
742 Market St.,
San Francisco, Calif.

Los Angeles Area

Atkin & McRae,
111 W. 11th St.,
Los Angeles, Calif.

California Testing Laboratories, Inc.,
1429 Santa Fe Ave.,
Los Angeles, Calif.

Eisenhauer, Ed, Jr.,
322 S. San Pedro St.,
Los Angeles, Calif.

Fess, Edward E.,
5905 Pacific Blvd.,
Huntington Park, Calif.

Groch Engineering Co.,
624 W. Ninth St.,
Los Angeles, Calif.

Herman, John
920 Santee St.,
Los Angeles, Calif.

Herr, A. V.,
5176 Hollywood Blvd.,
Los Angeles, Calif.

Kennard & Drake,
4686 S. Santa Fe Ave.,
Los Angeles, Calif.

Lewis & Walker,
111 W. 11th St.,
Los Angeles, Calif.

Los Angeles Testing Laboratory,
1300 S. Los Angeles St.,
Los Angeles, Calif.

Meco Assayers,
417 S. Hill St.,
Los Angeles, Calif.

Minerals Engineering,
417 S. Hill St.,
Los Angeles, Calif.

Osborne, Raymond G., Laboratories,
110 W. Ninth St.,
Los Angeles, Calif.

Pacific Platinum Works,
814 S. Spring St.,
Los Angeles, Calif.

Research Chemicals Laboratories (rare-earth analysis and research work),
831 N. Lake St., P. O. Box 431,
Burbank, Calif.

Sill, Harley A.,
1011 S. Figueroa St.,
Los Angeles, Calif.

LIST OF COMMERCIAL ASSAY AND TESTING LABORATORIES—Continued

Smith-Emery Co.,
920 Santee St.,
Los Angeles, Calif.

von Huene, Rudolph (thin sections),
865 N. Mentor Ave.,
Pasadena, Calif.

Ward, Paul (ceramic testing),
605 Mission St.,
South Pasadena, Calif.

Other Areas

Bishop Assay and Engineering Office,
318 N. Main St.,
Bishop, Calif.

Brooks, Alan M.,
Box 893,
Chula Vista, Calif.

Clarkson Laboratories,
724 Seventh Ave.,
San Diego, Calif.

Coast Laboratory,
1859 S. Van Ness Ave.,
Fresno, Calif.

Daily Chemical Laboratory,
Box 228,
Oroville, Calif.

Dietrich, Morse & Associates,
316 16th St.,
Sacramento, Calif.

Hornkohl Laboratories,
716 Truxton Ave., Box 1673,
Bakersfield, Calif.

Ott, E. J. N.,
130 Main St.,
Nevada City, Calif.

Raggio, A. J.
Jackson, Calif.

Rombaugh, M. D.,
3069 Del Paso Blvd.,
North Sacramento, Calif.

San Joaquin Research Laboratory,
8 W. Weber St., Box 1987,
Stockton, Calif.

Scheave, Harold,
232 Commercial St.,
Nevada City, Calif.

Smith-Emery Co.
Administration Bldg., Balboa Park,
San Diego, Calif.

Twining Laboratories,
2527 Fresno St., Box 1472,
Fresno, Calif.

Wallace's Lapidary & Assay Office,
Box 344,
El Centro, Calif.

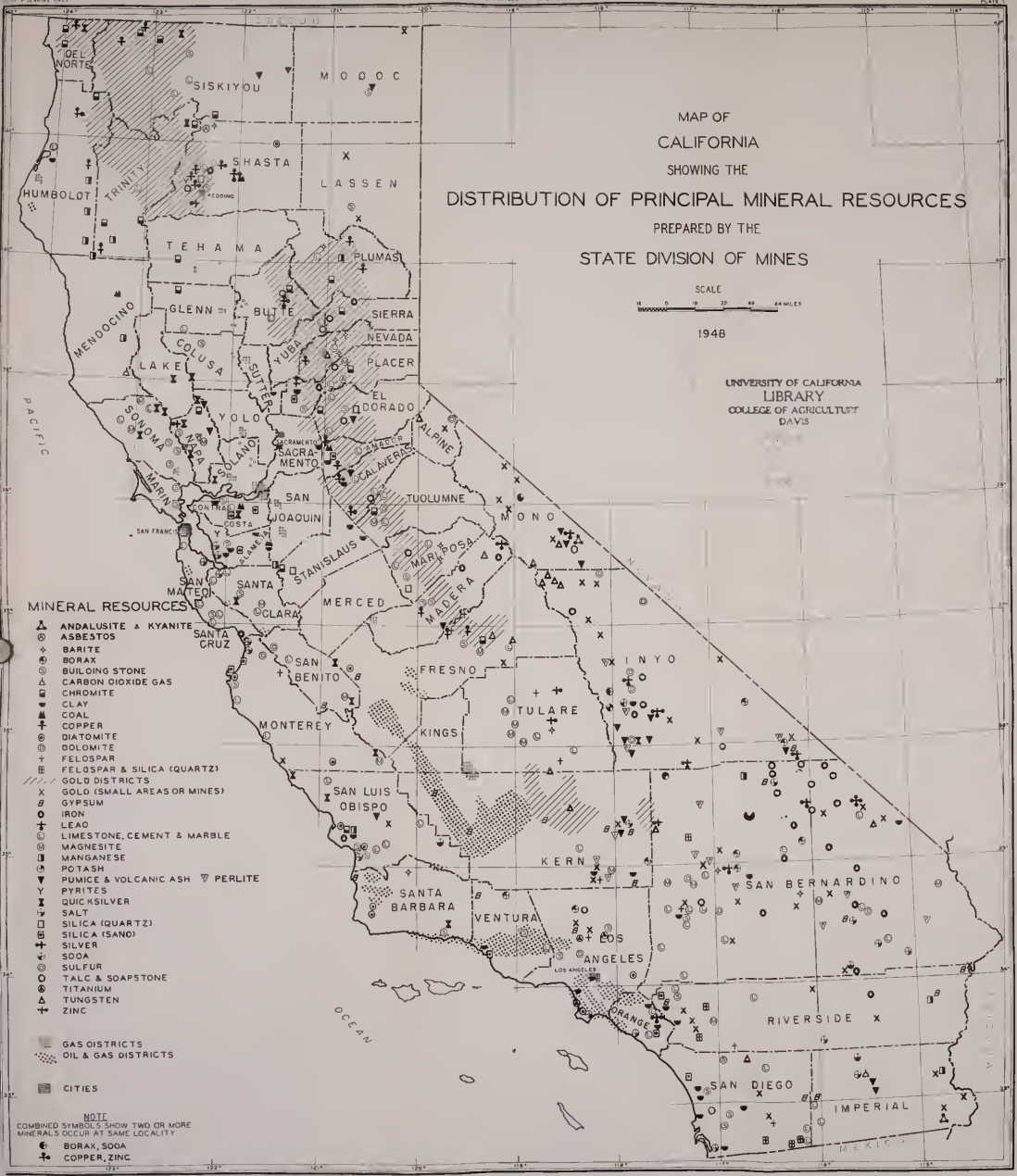
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DIVISION OF MINES
OLAF P JENKINS, CHIEF

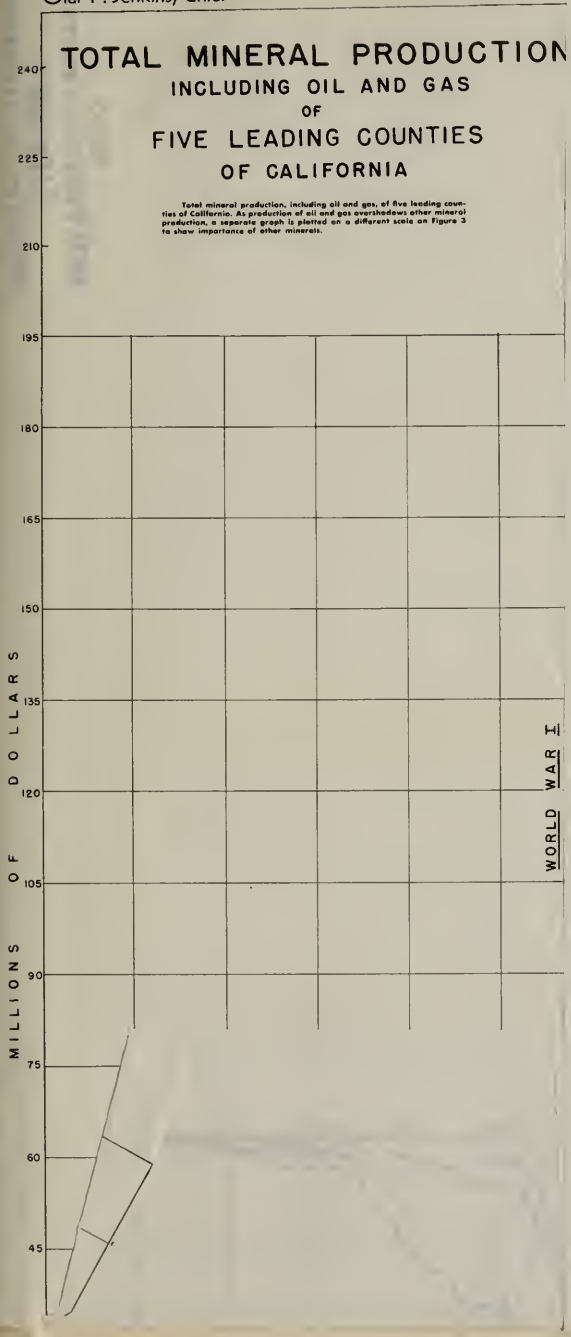
BULLETIN 142
PLATE 1




MAP OF
CALIFORNIA
SHOWING THE
DISTRIBUTION OF PRINCIPAL MINERAL RESOURCES
PREPARED BY THE
STATE DIVISION OF MINES
SCALE
1948
UNIVERSITY OF CALIFORNIA
LIBRARY
COLLEGE OF AGRICULTURE
DAVIS
MINERAL RESOURCES
ANDALUSITE & KYANITE
ASBESTOS
BARITE
BORAX
BUILDING STONE
CARBON DIOXIDE GAS
CHROMITE
CLAY
COAL
COPPER
DIATOMITE
DOLOMITE
FELDSPAR
FELDSPAR & SILICA (QUARTZ)
GOLD DISTRICTS
GOLD (SMALL AREAS OR MINES)
GYPSUM
IRON
LEAD
LIMESTONE, CEMENT & MARBLE
MAGNESITE
MANGANESE
POTASH
PUMICE & VOLCANIC ASH
PERLITE
PYRITES
QUICKSILVER
SALT
SILICA (QUARTZ)
SILICA (SAND)
SILVER
SODA
SULFUR
TALC & SOAPSTONE
TITANIUM
TUNGSTEN
ZINC
GAS DISTRICTS
OIL & GAS DISTRICTS
CITIES
NOTE
COMBINED SYMBOLS SHOW TWO OR MORE MINERALS OCCUR AT SAME LOCALITY
BORAX, SODA
COPPER, ZINC
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
NEVADA
COLUSA
YUBA
PLACER
LAKE
SUTTER
EL DORADO
YOLO
ALPINE
SONOMA
NAPA
SOLANO
SACRAMENTO
AMADOR
CALAVERAS
MARIN
SAN JOAQUIN
TUOLUMNE
CONTRA COSTA
MONO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
MADERA
MERCED
SANTA CRUZ
INYO
SAN BENITO
FRESNO
TULARE
MONTEREY
KINGS
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
PACIFIC OCEAN
MEXICO

Division of Mines
Olaf P. Jenkins, Chief

Sta
Departmen



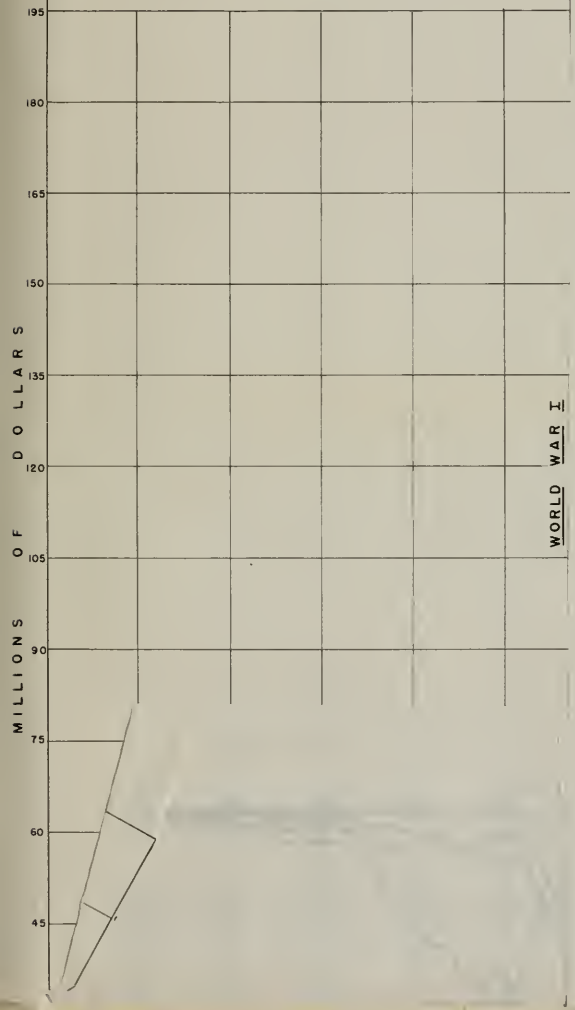


Division of Mines
Olaf P. Jenkins, Chief

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TOTAL MINERAL PRODUCTION
INCLUDING OIL AND GAS
OF
FIVE LEADING COUNTIES
OF CALIFORNIA

Total mineral production, including oil and gas, of five leading counties of California. As production of oil and gas overshadows other mineral production, a separate graph is plotted on a different scale on Figure 3 to show importance of other minerals.



Division of Mines
Olaf P. Jenkins, Chief

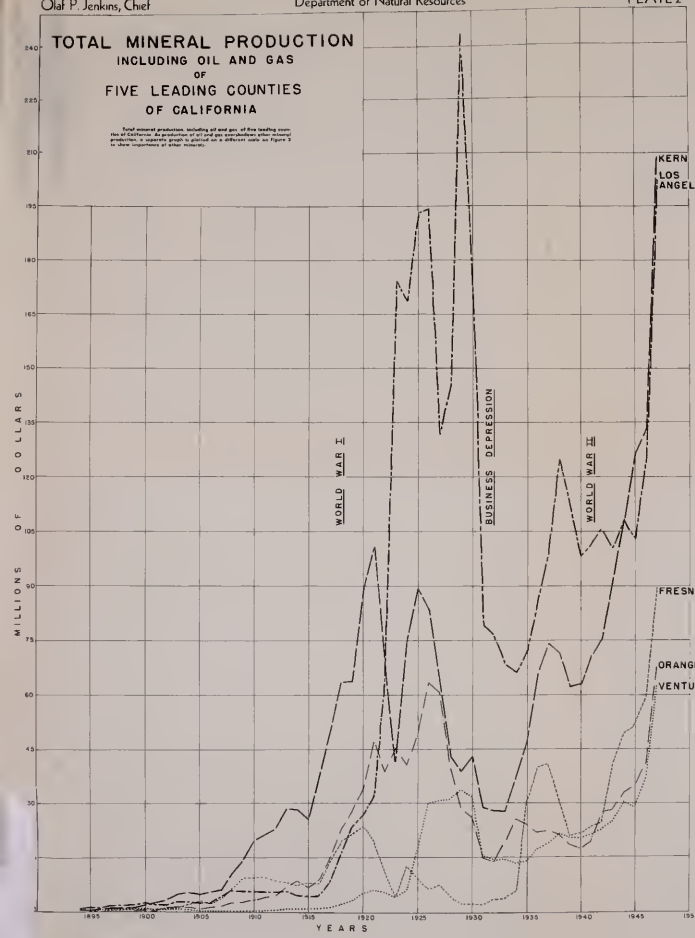
State of California
Department of Natural Resources

BULLETIN 142
PLATE 2

TOTAL MINERAL PRODUCTION

INCLUDING OIL AND GAS
OF
FIVE LEADING COUNTIES
OF CALIFORNIA

Total mineral production, including oil and gas, of five leading counties of California. As production of oil and gas overwhelms other mineral production, a separate graph is plotted on a different scale on Figure 3 to show importance of other minerals.



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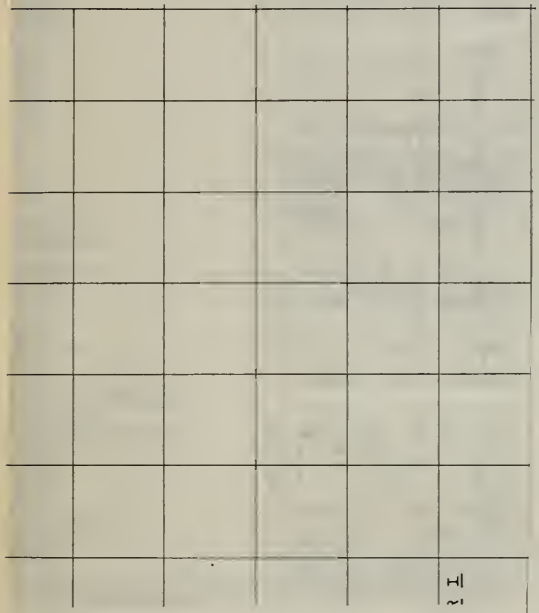
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Division of Mines
Walter P. Jenkins, Chief

State of
Department of I

MINERAL PRODUCTION
EXCLUDING OIL AND GAS
OF
SEVEN LEADING COUNTIES
OF CALIFORNIA

Mineral production, excluding oil and gas, of seven leading counties of California. Five counties that have lead recently are shown. Shasta County is shown because of large copper production in 1900 to 1918. Nevada County illustrates the trend of gold production.



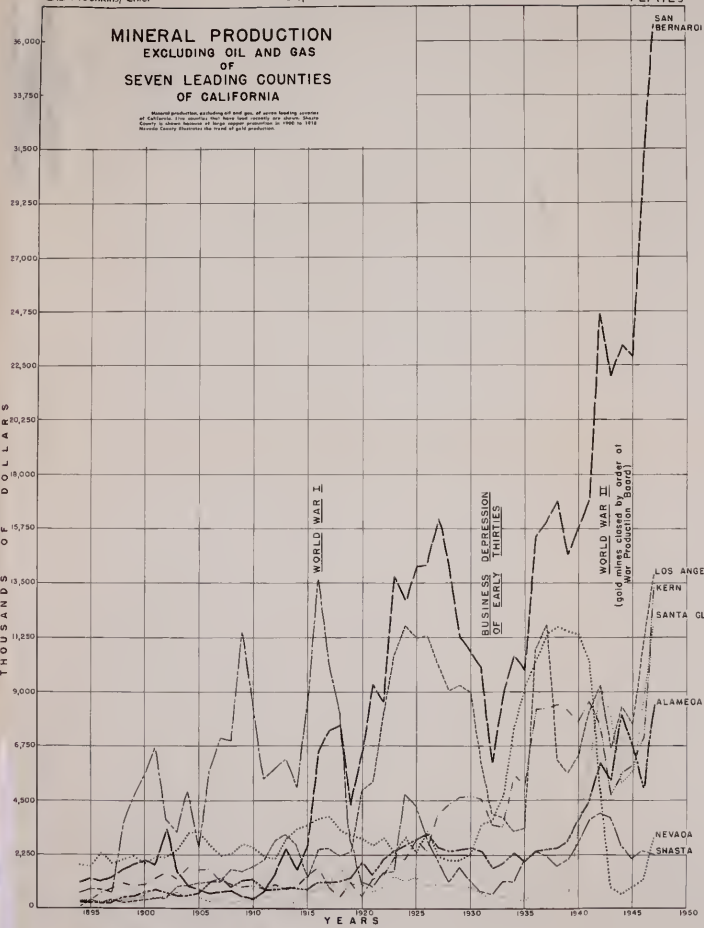
Division of Mines
Olaf P. Jenkins, Chief

State of California
Department of Natural Resources

BULLETIN 142
PLATE 3

MINERAL PRODUCTION
EXCLUDING OIL AND GAS
OF
SEVEN LEADING COUNTIES
OF CALIFORNIA

Mineral production, excluding oil and gas, of seven leading counties of California; five counties that have led recently are shown; Shasta County is shown because of large copper production in 1906 to 1918. Nevada County illustrates the trend of gold production.



ion of Mines
P. Jenkins, Chief

State of C
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POSITS PRODUCING COMMERCIAL AMOUNTS 1943-48
AMES & ADDRESSES NOTED IN DIRECTORY OF PRODUCERS
THER THAN NATURAL GAS & PETROLEUM)

POSITS OF SMALL PRODUCTION OR AS BY-PRODUCT
MINING FOR OTHER MINERALS.

POSITS, POSSIBLE COMMERCIAL VALUE. NOW IDLE.

ARENCES, LITTLE OR UNKNOWN COMMERCIAL VALUE
OTED IN REPORTS OF THE STATE MINERALOGIST)

ANTS NOW IDLE.

COMM

ALAMEDA
ALPINE
AMADOR
BUTTE
CALAVERAS
COLUSA
CONTRA COSTA
DEL NORTE
EL DORADO
FRESNO
GLENN
HUMBOLDT
IMPERIAL
INYO
KERN
KINGS

UELS																					
COAL	X			Δ	O			O			O			X	O	O				O		O
NATURAL GAS					Δ				▲					▲	▲	Δ				▲	▲	O
PETROLEUM								O						▲		O				▲	▲	
ETALS																					
ANTIMONY																			Δ	Δ		
ARSENIC					O			O					O	O						O		
BERYLLIUM																			O			
BISMUTH														O					O			
CADMIUM						Δ													O			
CHROMITE	X				X	Δ	Δ	X	O	▲	▲	Δ	▲	Δ							O	Δ
COBALT						O													O			
COPPER	X	O	▲	Δ	▲	▲	O	O	O	Δ	X	O	X	X	▲	Δ						O
GOLD		Δ	▲	▲	▲	▲	Δ		Δ	▲	Δ	O	Δ	Δ	▲	▲	O	O				
IRON ORE			O	O	O				O	O				O	O	X	O					
LEAD		Δ	Δ	O	Δ					Δ				X	▲	Δ						
MANGANESE ORE	Δ			Δ	X	Δ	Δ	O					Δ	▲	Δ	X						Δ
MOLYBDENUM ORE		O			O											▲						
NICKEL																						
PLATINUM GROUP			O	Δ	X				X					X								
QUICKSILVER		O					Δ	▲	Δ		Δ					Δ	X	Δ	▲			
SILVER	O	X	Δ	Δ	▲			O	Δ	O			O	X	▲	Δ						
TIN											O					O						
TITANIUM																						
TUNGSTEN ORE		Δ							O	▲					▲	▲						
VANADIUM																						
ZINC					▲	▲			Δ					O	▲	Δ						
TRUCTURAL MATERIALS																						
BITUMINOUS ROCK																						
BRICK & HOLLOW TILE PLANTS	▲			▲	⧗			▲				▲			Δ				▲			
CEMENT PLANTS						▲		⧗											▲			
GRANITE													▲									
LIME KILNS	▲									▲						⧗						
MAGNESITE	X																		X	X		
MARBLE				X	O							O	O		O	X	O					
ONYX & TRAVERTINE							O									X	O					
SANDSTONE	O			O		O	X		O			O	O				O					
SERPENTINE						X																
SLATE				O		X				▲		O				Δ						
STONE MISC. (CRUSHED ROCK, SAND & GRAVEL)	▲	Δ	Δ	▲	Δ	Δ	▲	Δ	▲	▲	▲	▲	Δ	▲	Δ	▲	Δ	▲	▲	X		
(GRINDING-MILL PEBBLES)						X																
DUSTRIAL MATERIALS																						
ASBESTOS	O		O	O	O	O		O		O	O	O					O					

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- DEPOSITS PRODUCING COMMERCIAL AMOUNTS 1943-48 (NAMES & ADDRESSES NOTED IN DIRECTORY OF PRODUCERS OTHER THAN NATURAL GAS & PETROLEUM.)
- DEPOSITS OF SMALL PRODUCTION OR AS BY-PRODUCT IN MINING FOR OTHER MINERALS.
- DEPOSITS, POSSIBLE COMMERCIAL VALUE. NOW IDLE.
- OCCURRENCES, LITTLE OR UNKNOWN COMMERCIAL VALUE (NOTED IN REPORTS OF THE STATE MINERALOGIST.)
- PLANTS NOW IDLE.

	ALAMEDA	ALPINE	AMADOR	BUTTE	CALAVERAS	COLUSA	CONTRA COSTA	DEL NORTE	EL DORADO	FRESNO	GLENN	HUMBOLDT	IMPERIAL	INYO	KERN	KINGS
FUELS																
COAL	X		△	○		○		○		X	○	○			○	
NATURAL GAS				△			▲			▲	▲	△			▲	▲
PETROLEUM						○				▲		○			▲	▲
METALS																
ANTIMONY													△	△		
ARSENIC			○		○					○	○				○	
BERYLLIUM													○			
BISMUTH										○			○			
CADMIUM				△									○			
CHROMITE	X		X	△	△	X	○	▲	▲	△	▲	△			○	△
COBALT				○									○			
COPPER	X	○	▲	△	▲	○	○	○	△	X	○	X	X	▲	△	
GOLD		△	▲	▲	▲	△		△	▲	△	○	△	△	▲	▲	○
IRON ORE			○	○	○			○	○			○	○	X	○	
LEAD		△	△	○	△				△				X	▲	△	
MANGANESE ORE	△		△	X	△	△	○				△	▲	△	X		
MOLYBDENUM ORE		○			○									▲		
NICKEL																
PLATINUM GROUP			○	△	X			X				X				
QUICKSILVER		○				△	▲	△		△				△	X	△
SILVER	○	X	△	△	▲			○	△	○		○	X	▲	△	
TIN										○				○		
TITANIUM																
TUNGSTEN ORE		△							○	▲				▲	▲	
VANADIUM																
ZINC				▲	▲				△				○	▲	△	
STRUCTURAL MATERIALS																
BITUMINOUS ROCK																
BRICK & HOLLOW TILE PLANTS	▲		▲	⧗			▲			▲		△			▲	
CEMENT PLANTS					▲		⧗								▲	
GRANITE										▲						
LIME KILNS	▲								▲				⧗			
MAGNESITE	X													X	X	
MARBLE			X	○							○	○		X	○	
ONYX & TRAVERTINE					○									X	○	
SANDSTONE	○		○		○	X		○			○	○			○	
SERPENTINE					X											
SLATE			○		X				▲		○			△		
STONE MISC. (CRUSHED ROCK, SAND & GRAVEL) (GRINDING-MILL PEBBLES)	▲	△	△	▲	△	△	▲	△	▲	▲	▲	▲	△	△	▲	X
					X											
INDUSTRIAL MATERIALS																
ASBESTOS	○		○	○	○		○		○	○	○				○	

COMMERCIAL MINERALS OF CALIFORNIA

▲ DEPOSITS PRODUCING COMMERCIAL AMOUNTS 1943-48 (NAMES & ADDRESSES NOTED IN DIRECTORY OF PRODUCERS OTHER THAN NATURAL GAS & PETROLEUM)

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X DEPOSITS, POSSIBLE COMMERCIAL VALUE. NOW IDLE

O OCCURRENCES, LITTLE OR UNKNOWN COMMERCIAL VALUE (NOTED IN REPORTS OF THE STATE MINERALOGIST)

⧗ PLANTS NOW IDLE

ALAMEDA · ALPINE · AMADOR · BUTTE · CALAVERAS · COLUSA · CONTRA COSTA · DEL NORTE · EL DORADO · FRESNO · GLENN · HUMBOLDT · IMPERIAL · INYO · KERN · KINGS · LAKE · LASSEN · LOS ANGELES · MADERA · MARIN · MARIPOSA · MENDOCINO · MERCED · MODOC · MONO · MONTEREY · NAPA · NEVADA · ORANGE · PLACER · PLUMAS · RIVERSIDE · SACRAMENTO · SAN BENITO · SAN BERNARDINO · SAN DIEGO · SAN FRANCISCO · SAN JOAQUIN · SAN LUIS OBISPO · SAN MATEO · SANTA BARBARA · SANTA CLARA · SANTA CRUZ · SHASTA · SIERRA · SISKIYOU · SOLANO · SONOMA · STANISLAUS · SUTTER · TEHAMA · TRINITY · TULARE · TUOLUMNE · VENTURA · YOLO · YUBA

FUELS

- COAL
- NATURAL GAS
- PETROLEUM

METALS

- ANTIMONY
- ARSENIC
- BERYLLIUM
- BISMUTH
- CADMIUM
- CHROMITE
- COBALT
- COPPER
- GOLD
- IRON ORE
- LEAD
- MANGANESE ORE
- MOLYBDENUM ORE
- NICKEL
- PLATINUM GROUP
- QUICKSILVER
- SILVER
- TIN
- TITANIUM
- TUNGSTEN ORE
- VANADIUM
- ZINC

STRUCTURAL MATERIALS

- BITUMINOUS ROCK
- BRICK & HOLLOW TILE PLANTS
- CEMENT PLANTS
- GRANITE
- LIME KILNS
- MAGNESITE
- MARBLE
- ONYX & TRAVERTINE
- SANDSTONE
- SERPENTINE
- SLATE
- STONE MISC (CRUSHED ROCK SAND & GRAVEL)
- (GRINDING-MILL PEBBLES)

INDUSTRIAL MATERIALS

- ASBESTOS
- BARITE
- BENTONITE
- CALCIUM SILICATE
- CARBON DIOXIDE
- CLAY
- DIATOMITE
- DOLOMITE
- FELDSPAR
- FLUORSPAR
- GARNETS (ABRASIVE)
- GEMS
- GRAPHITE
- GYPSUM
- LIMESTONE
- LITHIA
- MICA
- MINERAL PAINT
- MINERAL WATER
- PERLITE
- PUMICE (LUMP)
- VOLCANIC ASH
- PYRITES
- SHALE OIL
- SILICA (QUARTZ)
- (GLASS SAND)
- SILLIMANITE-ANDALUSITE-KYANITE GROUP
- SOAPSTONE
- TALC & PYROPHYLLITE
- STRONTIUM
- SULPHUR
- ZIRCON

SALINES

- ALUMS NATURAL
- BORATES
- BROMINE
- CALCIUM CHLORIDE
- IODINE
- MAGNESIUM SALTS
- POTASH
- SALT
- SODA

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